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DISPERSAL, AMOUNT OF INBREEDING, AND LONGEVITY IN A LOCAL POPULATION OF PRAIRIE DEERMICE ON THE GEORGE RESERVE, SOUTHERN MICHIGAN*

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INTRODUCTION

It is a biological truism that the dispersal of some members of every species at some stage in their life cycle is essential for the existence of that species. No form of plant or animal is without some adaptation for dispersal, otherwise it would exist on earth only as a solid colony. The ability to disperse enables a species to reinvade depopulated localities and to extend its range to such other favorable habitats as exist or may arise from time to time. The distance of dispersal of individuals determines the amount of inbreeding and the rate of spread of genetic factors throughout a population, thus controlling in part the manner and rate of evolution of local races. Knowledge of dispersal rate acquires economic importance when one wishes to eradicate or control a pest species. Little is known about the forces which initiate and maintain the dispersal movements of animals, and there is great need for quantitative and analytical studies on the rates of dispersal of different species. We need to know more about the time relationships of movements, the extent of randomness of dispersal patterns, and the degree of variation of the regression curves with the same population at different seasons and years. Further information is necessary to determine the role which population density plays in affecting the course and extent of movements, and to determine what ecological factors are operating on rates of dispersal.

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This study was undertaken for the purpose of determining the distance that individuals of the prairie deermouse (*Peromyscus maniculatus bairdii* Hoy and Kennicott) disperse from their places of birth to their established homesites. In the literature I find no previous example in which a natural animal population was studied in such a way that quantitative data on the rate of dispersal were obtained. There are many instances of records of the dispersal of individual organisms. This is especially true with banded birds (for a review of the literature see Farner, 1945) and with game animals which have been marked and then released. In these instances the distance of dispersal is known for only a few individuals, and nothing is known about the movements which their sibs made.

As a result of this investigation, in which more than 1200 prairie deermice were handled a total of more than 4000 times, many data have been accumulated on other phases of the biology of these animals. Of particular bearing on the problem of evolution of local races is the information obtained about the amount of inbreeding which took place in the deermouse population.

ACKNOWLEDGMENTS

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Michigan. The final draft has been completed at the University of California. The construction of the nest boxes was supported in part by the National Youth Administration.

METHODS OF STUDY

Description of the Nest Boxes

Arboreal nest boxes have long been used in bird studies. They were employed successfully for fox squirrel investigations by Hesselschwerdt (1942) and Terrill and Crawford (1946). The nest-box technique used in this investigation was first designed by Nicholson (1941) for woodmice (*Peromyscus leucopus noveboracensis*) following suggestions by Dice. Blair (unpublished) later modified the technique for live-trapping deermice, and it is his nest box which I used, except for a few older nest boxes of a different style, which had been used earlier by Nicholson (1941) and by Bujak (unpublished). Most of the nest boxes were partly buried in the ground. The deermice entered the cotton-filled nest chamber by means of the open, sloping tunnel (Pl. I, Fig. 2). Fifteen of the 136 nest boxes built were used in two locations, bringing to 151 the total number of nest-box locations that contributed data for this study (Map 1). Of the 136 nest boxes, eighty-four were of the type which is illustrated (Pl. I, Fig. 1), nineteen were similar in style but had a nest chamber measuring eight by eight and one-half by seven and three-fourths inches (the most satisfactory size), ten had two air spaces, a longer tunnel, and were buried about twice as deep, and twenty-three were smaller than the ones illustrated, were without tunnels, and were not buried.

The nest boxes were constructed from three-fourths-inch pine, the tunnels from laths, and the tops from three-fourths- and three-eighths-inch wood and roofing paper. The boards were soaked in hot linseed oil and were fastened together with glue and screws. Wire hooks prevented the wind or large animals from removing the tops.

The purpose of the air space (Fig. 1) above the nest chamber was to provide insulation. By taking the maximum and minimum temperature readings both in the air space and in the nest chamber from March 19 to October 12, 1942, I found that the insulating effect of the air space resulted in a more uniform temperature in the nest chamber. During the warmer period of summer, the temperature in the air space section of the nest box became as much as 23° F. higher than that in the nest chamber. It averaged 11° F. higher for the seven-month period when the temperatures were recorded. The minimum temperatures in the air space also registered below those of the nest chamber. During the cold weather, the nest chambers were usually only 2 or 3° F. warmer than the air space, but the nest chambers were never much below freezing. The principal effect of the air space, therefore, was to prevent the nest chamber from becoming overheated during the summer rather than to keep it warmer during the winter.

The union of the tunnels to the boxes was not fully watertight, and many of the nest chambers became wet during the spring thaws and heavy rains when water seeped through the cracks. Holes drilled through the floors of the nest chambers were not effective in draining the water out of the nests, but instead permitted more to come in. Sawdust and excelsior placed beneath the cotton became foul after it became wet, and its use was discontinued. Ants were a nuisance on a number of occasions, for they took advantage of the opportunity to deposit their excavated earth in the nest boxes instead of carrying it up to ground level.

A few of the nest boxes were examined after they had been buried for more than five years. They had been unattended during the last three years because of the war; nevertheless, a family of deermice was living in a cotton nest in one of the boxes. Ants had filled many of the nest boxes with dirt causing much of the wood to decay. The nest box technique for studying deermice could be improved by increasing the insulation from summer heat, reducing the tunnel size to about three-fourths of an inch in diameter, and making the tunnel connection to the nest chamber waterproof.

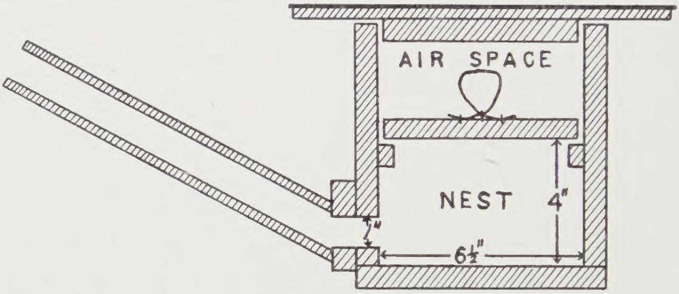
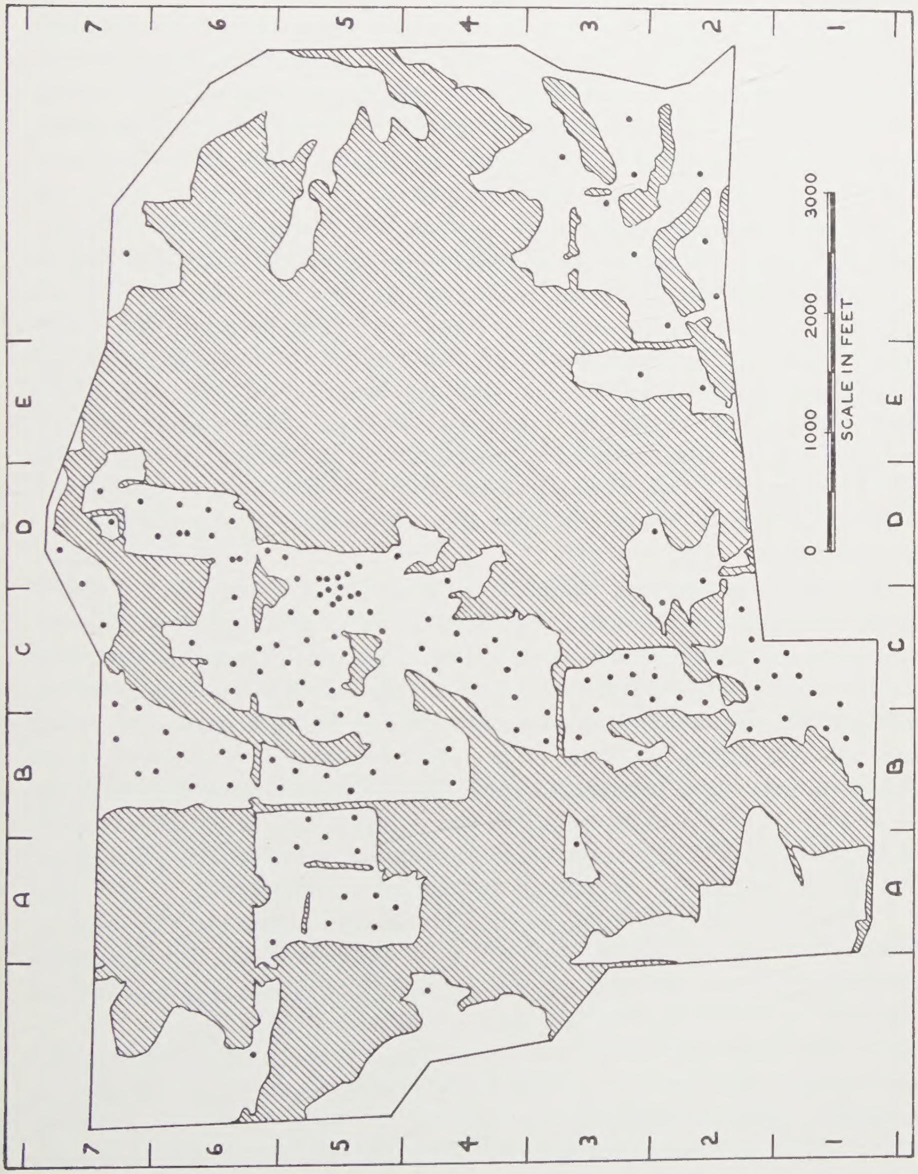


FIG. 1. Cross-section diagram of a nest box.

Field Operations

The nest boxes were the principal method by which the deermice were caught, because the mice readily accepted the boxes as homesites. When boxes were used in this manner, no bait was necessary, no time was lost preparing a set, there was a minimum of disturbance to the animals, and the deermice were observed in a homesite which they had selected. Occasionally, the nest boxes were examined at night. This gave information on deermice living in the vicinity of a nest box but not in it. When the same individual was observed in the daytime in one nest box and found at night visiting another, it gave indications of the size of the home ranges.

The nest boxes were placed within the boundaries of the Edwin S. George Reserve, Livingston County, Michigan. This Reserve comprises over 1200 acres of woodlots, swamps, and open fields (Pl. II, Fig. 1) all of which were previously included in farms. The entire area is now game-fenced and is reverting to a natural state. The study area comprises approximately 300



MAP 1. The Edwin S. George Reserve. The grassland areas are not shaded and the dots mark the locations of the nest boxes.

acres of grassland (Map 1). The greater part of this open land is bordered by oak-hickory woods. At the north and south ends of the study area, the grassland is continuous with the surrounding open farmland.

Blair (1940*b*) has described in detail the ecological associations inhabited by deermice on the George Reserve. His study plots, which he considered as part of the bluegrass association, were included in my area of study. The deermice were most abundant in well-drained areas that had only a sparse cover of grass and other herbs. They apparently prefer the more open habitats to those with a denser growth of grass.

Deermice have been found only in open fields on the George Reserve. Burt (1940) and Nicholson (1941) both live-trapped other small mammals in the woods adjacent to the fields inhabited by deermice, but they did not catch any deermice in the woods. It has been shown, however, that a few deermice must at times travel through partial barriers of woods and swamps, because individuals appeared in a small section of open grassland which was completely surrounded by woods and swamps. When Blair (1940*b*: 293) released forty-five deermice on a plot which was surrounded by woods and swamps, individuals were recaught after they had moved through the woods and swamps. "Most of the mice apparently moved through the marshes."

The nest boxes were not placed in the field at a uniform distance apart, but instead they were buried at locations where I thought they were most likely to be frequented by deermice. Most of the nest boxes were separated from each other by distances of one hundred and fifty to three hundred feet (Map 1). Ten nest boxes were placed in one area which was only about three hundred feet in diameter; at two other locations a pair of nest boxes was placed just three feet apart; and a third pair was placed twenty-five feet apart to see what effect the extra boxes might have in attracting additional deermice into those areas. The increased number of nest boxes, however, did not increase the deermouse population in those areas.

The field study covered a period of two years, beginning November 1, 1940, and ending October 12, 1942. Most of the nest boxes were examined almost every week, some every other week, and a few outlying nest boxes less frequently. More than 4700 nest box observations were made.

The usual procedure for examining the nest boxes was to start at sunrise each Sunday. This gave me one full day a week for field work. On eighteen of the 101 weeks of field study no observations were made, but, since on twenty-four trips I was in the field for more than one day, observations were made on a total of 107 days.

To examine a nest box, a stick was inserted down the tunnel entrance to the nest chamber. The top and inner cover of the box were then removed. The deermice did not attempt to jump out of the nest box, but instead they clustered around the blocked tunnel trying to get out the way they had entered. It was easy to thrust a hand or a pair of rubber-tipped, twelve-inch forceps into the nest chamber and to pick up a deermouse by his tail. The hold was then shifted to the back of the mouse's neck, which was clasped by thumb and forefinger. In this position it was easy to manipulate the mouse in order to mark it, to read its number if already marked, to collect parasites, or to observe its breeding condition. These data then were recorded in my field notes. If there was more than one animal in the nest box, the first was put in a cloth bag and the top of the bag tucked under my belt while the second one was being handled.

Every time a mouse was handled, all of its markings were checked, including individual toe and ear numbers, sex, the number of the nest box at which the mouse was first marked or last observed, and the additional toe which had been removed from litters under three weeks of age. The monel band numbers of certain individuals so marked were frequently checked. For future identification of the animals other individual characteristics also were noted, for example, a short tail or no tail at all, a missing foot, a white mark on the forehead, color alterations such as dark hairs on the hind toes, an extra toe on the outside of the forefoot of one male, and any scars.

If the cotton batting in the nest was wet or badly soiled, it was replaced with fresh cotton. Samples were collected of the nuts and seeds which were stored in the nest boxes. Maximum and minimum temperature readings were recorded for twenty-one weeks in the nest chamber and air space section of one nest box. Holes were drilled through the inner covers of many other boxes so that the temperature of the nest chamber could be obtained by inserting a thermometer through the hole without having first to remove the cover.

In late summer fewer deermice lived in the nest boxes than lived there during the rest of the year. This was probably caused in part by the warmth of the nest boxes. In spite of this, the animals continued to visit the boxes during their nightly wanderings.

In order to obtain records of the deermice living adjacent to the nest boxes, sixty-two multiple-catch traps were constructed. They consisted of a metal door which could only swing inward, and they were inserted in the entrances of the nest box tunnels. The mice merely had to push up the swinging door and proceed into the nest chamber. With this type of trap several mice were often caught simultaneously. It was unnecessary to bait the traps, for the mice visited the nest boxes regularly. When I examined the nest boxes during the day, I set the multiple-catch tunnel traps in the unoccupied nest boxes and re-examined them the following day or during the night.

In addition to the above methods of capturing the deermice, I used 172 single-catch live traps of the type described by Blair (1941). They were used primarily to check on the success of the nest-box technique for catching the entire population of deermice, but they also furnished valuable records in the late summer when fewer mice were living in the nest boxes.

The deermice were marked in the field at the place of capture by a method similar to that which Burt (1940) used in his studies of the woodmouse. By notching different sections of the ears and punching not more than one hole in each ear with a poultry punch, numbers from 1 to 399 inclusive could be assigned. In addition to ear numbers, one toe was clipped with a small pair of scissors. The toes were lettered alphabetically from *A* to *R* inclusive. This made it possible to mark 399 different individuals for each toe clipped. With this combination of ear-notching and toe-clipping more than seven thousand mice could be given individual numbers without the necessity of cutting off more than one toe.

Since many of the deermice were observed in the nest boxes shortly after birth, it became necessary to find a way to mark those which were only one day old, for it was always possible that the mother might move the litter out of the nest box into an adjacent natural home before the immature mice became old enough to have their ears marked. Immature deermice can be marked when they are one day old by cutting away the tip of the growing point of one toe. If about one-sixteenth of an inch of flesh is removed, it prevents that toe from growing. All the members of one litter were marked by cutting off the same toe. The young were then marked individually after they became about three weeks old, by ear-notching and toe-clipping, thus freeing the original toe mark for use on another litter.

Before I had completed my field studies, F. N. Hamerstrom, Jr. and Frances Hamerstrom commenced a study of the predators on the George Reserve. Since it appeared to be an excellent opportunity for co-operation between us, I put bands or rings on the mice. Small mammals had earlier been marked with a metal band by Chitty (1937). Scott (1942) marked prairie deermice with the monel metal fingerling tags commonly used to mark fish. He attached the tags deep in the base of the ears. Bird bands were also tried on caged deermice. The bands proved to be too soft, and the mice chewed them off in one night. Bands made of monel were not mutilated by the mice. About three hundred deermice were banded in addition to their other markings. The bands were placed upon an ankle of one of the hind legs. They were not entirely successful, and in at least nineteen cases the feet became swollen. I amputated the banded feet of six of these animals, and I found three instances in which apparently the mouse had amputated its own foot. Several of these amputees were observed for some time after one of their hind feet had been removed. One male which was not banded had his left hind foot missing when he was first observed in a nest box. He lived for at least twenty-one weeks and during this time sired two litters. The bands did not prove to be entirely satisfactory, and I believe their use on mice is justified only when intensive predation studies are being conducted. The bands also became too tight on the legs of some of the animals marked by Chitty (1937).

SOME ECOLOGICAL FACTORS AFFECTING MOVEMENTS, INBREEDING, AND LONGEVITY

Use of Natural and Artificial Homesites

Little is known about the natural homes of prairie deermice. Dice (1932) discovered several burrows excavated by the deermice under driftwood along the beach of Lake Huron, Michigan. I observed two burrows, destroyed by foxes, which probably had been occupied by deermice. These burrows were shallow and contained caches of weed seeds and also cotton which had been removed from nest boxes. Deermice are willing to occupy burrows that are at least several feet deep, for they often used spermophile burrows and the few nest boxes which were buried several feet in depth. It appears, however, that they possess an instinct for constructing only shallow and relatively simple burrow systems and that they frequently use abandoned burrows which have been made by a different species of animal.

In a laboratory experiment with prairie deermice and woodmice (*P. l. noveboracensis*) both species proved they were capable of excavating burrows, but they were reluctant to dig and did so only when they had no other means of concealing themselves. They did not leave mounds of dirt at the entrances to the burrows, and they continued to plug and reopen the different entrances. When offered cotton nest sites, they abandoned their burrows.

When one winter aggregation of mice was not living in one of the nest boxes, it occupied part of an abandoned fox den, as was indicated by the tracks in the snow. At the same time cottontails were using another entrance of what appeared to be part of the same den. Some of the burrows which the deermice visited and lived in during the winter were found in the spring, when they were examined, to be in use also by spermophiles. Blair (1940*b*) noted that trapped deermice frequently went into "apparently abandoned" spermophile holes when released. Unfortunately, the simple experiment of releasing deermice in burrows known to be occupied by spermophiles was not carried out.

Live-trapping indicated that every prairie deermouse frequented a nest box if one was available in its home range. When a mouse was not living in a nest box, it continued to visit one or more boxes during its nightly wanderings. Therefore, traps usually were set only near unoccupied nest boxes or known holes, because many more mice were caught near these refuges than were taken in the other traps placed at random in the fields.

Six hundred and seventy-five deermice were born in the nest boxes (Pl. II, Fig. 2) or were moved into them by their mothers soon after birth. A few mice probably were born in natural homes in the vicinity of a nest box. This was especially true in late summer when the boxes were too warm, but in this season few litters were produced.

The animals apparently liked to eat their food near a quick retreat from predators, for there were ample signs at the entrances of all the tunnels indicating that mice had eaten food there. Tracks in the snow showed that they would carry their seeds some distance in order to eat under the security of a near-by tunnel.

Another good reason for believing that the deermice had a considerable liking for the nest boxes is that they usually continued to live in them even after I had used a poultry punch on their ears, clipped one or two toes with a pair of scissors, put a monel band on one leg, removed the immature mice from the teats of nursing females, collected parasites if present, changed their nesting material when it was soiled, and even stretched a few mice in order to take measurements of them. By rechecking some of the nest boxes the same day to see if the animals left the boxes after being disturbed, I found that some were gone, but most of these were back in the same box when it was examined a week later.

The availability of homesites is generally considered to be an important factor in limiting the density of all natural populations. It is difficult to analyze what effect the artificial nesting sites with the clean cotton batting had upon the populations of deermice on the George Reserve. The presence of the artificial homesites modified some of the minor movements of the mice, particularly with regard to the boundaries of their daily home ranges.

To determine the effect of the boxes on the normal movements of the mice, ten nest boxes were placed in an area having a diameter of less than three hundred feet. At two other locations nest boxes were set out in pairs. In another area two boxes were placed only twenty-five feet apart. Additional mice apparently were not attracted into any of the above areas where extra artificial homesites were situated. The only difference noted was that the deermice living in the areas with extra boxes changed their homesites more frequently than did the mice that occupied the more widely separated boxes.

Other Animals in the Nest Boxes

Many kinds of animals other than prairie deermice inhabited the nest boxes. The following list includes the more important ones and the number of individuals of each kind. The number of bumblebees refers to colonies or to partial colonies composed of solitary queens and eggs.

	Records
Prairie deermouse (*Peromyscus maniculatus bairdii*)	1228
Woodmouse (*Peromyscus leucopus noveboracensis*)	255
Bumblebee (*Bombus*)	104
Salamander (*Ambystoma*)	18
Striped spermophile (*Citellus t. tridecemlineatus*)	14
Short-tailed shrew (*Blarina brevicauda kirtlandi*)	10
Bog lemming (*Synaptomys c. cooperi*)	8

House mouse (*Mus musculus*)	8
Least shrew (*Cryptotis parva*)	7
Blue racer (*Coluber constrictor flaviventris*)	6
Meadow vole (*Microtus p. pennsylvanicus*)	5

Queen bumblebees frequently attempted to establish colonies in the nest chambers. I removed most of these colonies from the nest boxes in order to get more mouse records. The mice did not molest the solitary queens or colonies of bumblebees as far as I was able to determine. The queen bumblebees probably selected boxes that were not being used by mice at the time. After a colony of bumblebees had become large, the deermice would not go into the nest chamber even for sunflower seeds which were placed there, although they would go part way down the tunnels to get the seeds. A male and a female deermouse, however, were observed in one nest box which contained three bumblebees and some eggs. Another male deermouse was observed in the air-space section of a nest box which at the same time had a few bumblebees living in the nest chamber below. In a similar instance a male woodmouse had squeezed past the partition and was living in the air space section of a nest box which contained bumblebees. All of the above mice, however, had to use the same tunnel entrances by which the bumblebees entered. When a male deermouse was trapped in a box containing a large colony of bumblebees, he was apparently not harmed, and he killed and ate three bumblebees. Sunflower seeds which were also in the nest chamber at that time were not eaten by the male mouse. It is suggested that there is a marked competition for homesites between bumblebees and deermice, for they both frequently use the abandoned burrows of other animals. Wood (1872) has reported the use of rodent burrows by bumblebees.

Two hundred and fifty-five woodmice were observed in the nest boxes 480 times. Nearly all of these observations were made during winter months. Only thirteen litters of woodmice were born in the nest boxes. Prairie deermice and woodmice were together in nest boxes only ten times, and these associations occurred in boxes which were near woods or in the vicinity of a tree. These two species of mice occurred together principally in the winter time when neither was breeding. One female deermouse with an open vagina was found in a nest box with a male woodmouse which was in breeding condition. It is known that these species of *Peromyscus* do not hybridize, for Dice (1933*b*) attempted sixty-nine cross matings between them. I attempted two cross matings between *maniculatus bairdii* males and *leucopus noveboracensis* females. The female woodmice which were used in these matings were nursed to maturity by a female deermouse. I also attempted one cross mating between two males of *noveboracensis* and one female of *bairdii*. The female deermouse used in this experiment had nursed to maturity the two male woodmice which then were left with her.

A deermouse and a bog lemming (*Synaptomys*) were once observed together in a nest box. A male woodmouse was present in the same box with a female bog lemming whose vagina was open, but there is no suggestion that these two genera would cross.

On one occasion when a nest box was examined, two deermice were in the air-space section of the nest box which is between the roof and the inner cover, and at the same time a spermophile was in the nest chamber below. The spermophile had been in that nest box when it had been examined two weeks earlier. When the top was taken off the nest box, the mice squeezed past the partition and went down into the nest chamber with the spermophile. Both species got along harmoniously, but that may have been because all of the animals were more frightened of me than they were of each other. Twelve days later when that nest box was next examined, the remains of one of the above mice were found in the nest chamber.

One salamander was eaten in a nest box. I suspect that it was eaten by a shrew. I found eighteen salamanders in the nest boxes, sixteen in October and one each in September and December. There seems little doubt that the boxes which housed the salamanders were also being frequented by deermice at night. Only one salamander hibernated in a nest box. It was observed seven times between December 15, 1941, and March 9, 1942. When handled while hibernating, it produced a copious, milky secretion, opened its eyes, and crawled very feebly. This secretion may be noxious to the mice. A male woodmouse was observed on one occasion in the same nest chamber with an active salamander.

Food and Its Storage

There was no indication that the presence of a greater or lesser food supply in different areas affected the movements of deermice to any great extent. Food supply, quantity and quality, may be an important stimulus for mass migrations of mammals, but it does not bring about the normal dispersal pattern of deermice whereby a certain proportion of the offspring moved from their birthplace in varying directions and for varying distances. The deermice sometimes made dispersal movements from a greater to a lesser food supply. They often dispersed when food was abundant, but never dispersed during the winter time when food was scarce.

Bush clover (*Lespedeza*) was the most frequent kind of seed stored in the boxes by the winter aggregations of mice, yet the deermouse population was not noticeably increased in the immediate vicinity of patches of bush clover. However, if bush clover plants were present within their winter home ranges, tracks in the snow indicated that such patches of bush clover were frequently visited by the mice. According to the signs in the snow, they climbed the stalks and cut the stems just below the seeds. The stalks were one to three feet high, and in one instance apparently the weight of a mouse bent the top of a bush clover plant down to the snow.

Large quantities of weed seeds were cached in the nest boxes. The mice began storing food about the middle of October. No food stores were maintained later than the early part of March. These food caches enabled the animals to remain in the boxes during severe winter weather. The largest cache occurred in a nest box in which twelve deermice resided. In less than one month 1050 cc. of weed seeds, 565 acorns, and 6 deer pellets were stored in the box. The acorns had to be transported by the mice for a distance of at least 120 feet. This box was one of those with a large nest chamber, otherwise such a large hoard would not have been possible.

When deermice had their home range adjacent to woods they ate many acorns. In addition to weed seeds and acorns, the animals ate grasshoppers and other insects. Some lichens apparently were eaten in the winter. Samples of the stored food were collected, and the total quantities in each nest box were measured. This material will be analyzed at a later date. Cogshall (1928) conducted laboratory tests on the kinds of food which deermice prefer (for additional comments on the food habits of *Peromyscus* see Hamilton, 1941*b*).

Deermice are aided in storing food by having buccal pouches (Hamilton, 1942). I have observed caged deermice filling their internal cheek pouches until they were considerably distended, even though the seeds were being transported for only about six inches. Deermice are very exacting in their food stores, frequently sorting the different kinds of seeds.

Social Behavior

Prairie deermice lived in small social groups which most frequently were composed of one or both parents together with their young. In winter, larger aggregations were formed, and these groups of mice occasionally consisted of unrelated mice of the same or of a different species.

The mother of a family is readily recognized by her presence with her young, which often were attached to her nipples when they were observed in a nest box. The male parent of a family is more difficult to determine and in no case can one be positive of the father. The circumstantial evidence is fairly good when one male is frequently with the same female, especially if they are together at the time of impregnation, estimated as being about three or four weeks prior to the birth of the litter.

It was difficult to get much evidence on paternal behavior with the nest box technique. Weekly observations of the boxes, however, frequently showed a continued association of the males with the females and offspring, and if they were not in the nest boxes with the females and offspring, they would be within the home range of that box and often in an adjacent nest box. Horner (1947) described instances in which male laboratory deermice assisted their mates in the care of litters by washing the young, putting the young beneath them to keep them warm, aiding in nest building, and watching out for the general welfare of the young.

An interesting record of family relationships was obtained by trapping. A female and her four offspring, about twenty days of age, were observed in a nest box. The male parent was not in the box. On that day traps were set near unoccupied nest boxes. When I examined the traps on the following morning, the four twenty-day-old young and their father were in a trap 300 feet from the nest box in which the young had been the previous day. This indicates that not only did the four young mice remain together during their nightly wandering, but that the father also was with them. All five animals must have been close together to have been caught simultaneously in a single-catch live trap three hundred feet from their home. The male was assumed to be the father, for he had previously been paired with the female and no other males had been recorded in that local area.

During the breeding season there was usually just one pair of deermice living in a nest box and the surrounding home range, although, at times, irregular combinations of mice with respect to age and sex occupied the same nest box. In areas where the sex ratio was not equal, as many as three females lived in the same nest box with one male, and as many as three males lived in one nest box with one female. After a mouse became sexually mature, it remained for the rest of its life in the same local area, seldom moving its home range more than five hundred feet at a time. The animals apparently did not make very extensive movements in search of mates after they were sexually mature. Consequently, the above-mentioned irregular sex ratios occasionally resulted. In several instances a male or a female apparently remained alone and unmated in its home range for several months during the breeding season before a prospective mate appeared in the area.

Three cases were observed in which two litters of deermice were being reared simultaneously in the same nest by two different mothers (Fig. 19). This certainly suggests that there is little territorial defense among deermice. In one of these cases, the two females with litters in the same box were a mother and daughter. When two families lived in the same nest box, it is probable that the females nursed each other's young. This made it difficult to be certain which litter belonged to which female. In laboratory experiments conducted by W. Frank Blair and myself, we observed that female deermice often stole each other's young if they chose different nests, and nursed each other's young when they lived in the same nest. Female deermice nursed immature woodmice (*noveboracensis*) when I put them in their cages, and female woodmice readily accepted immature deermice. Many other small rodents apparently accept foster offspring even if of a different species. Ackert (1910) cited a case of a female white-footed mouse adopting four halfgrown house mice which were twice the size of her offspring. Shadle (1945) had a white rat which nursed six house mice to maturity along with her litter of nine young.

Some female deermice produced all their litters in the same nest box, while others used a different box for each litter. If a female produced another litter immediately after weaning her previous one, she was likely to select a new nesting site for the second litter. The family bond was the strongest during the birth of the last two litters in the fall and in the winter seasons. At this time of the year the offspring of both litters remained in the same box with their mother. The male was more often in the box with the rest of the family in the late fall and winter.

Winter aggregations of family units contained from a few to more than a dozen individuals. Unrelated mice occasionally became associated with these family units in the winter. Woodmice (*noveboracensis*) were associated with deermice in ten of the aggregations. One aggregation contained ten deermice and three woodmice.

It is important that the young mice do not disperse in the late fall, for an increase in the number of animals in an aggregation reduces the amount of individual body-heat loss. This decreases the amount of food which is required by each animal, although the total amount of food consumed by the mice increases as the number of individuals in an aggregation increases. I have demonstrated with caged animals placed outdoors during the winter that the amount of food required by each individual decreases as the number of animals living together increases. The number of individuals in each of these cages ranged from one to four.

Selection of Mates

It is of prime importance to know whether mating is random in the prairie deermouse or if there is assortative mating due to psychological, sexual, or other stimuli which produce certain specific mating preferences in the population. No evidence of any preferential mating among these deermice was secured, but the method of study was not designed to secure information on this point. There seemed to be no bar to the mating of close relatives, and parent-offspring matings and pairing between sibs occurred when conditions were such that these related mice happened to be together at the time when they became sexually active. The dispersal stimulus results in a scattering of related mice from their birthplaces and thereby often reduces the amount of close inbreeding which occurs. The stimulus or impulse to disperse occurs just prior to the breeding period, and mates, if present, were selected immediately following this movement, apparently irrespective of their blood relationship. Winter aggregations separated in the spring, but sometimes one or two offspring remained in the nest with one or both parents. Unrelated dispersants appeared in many of the boxes at this time.

The factors determining the choice in selection of mates are not well known for any vertebrate species. Hahn (1937) wrote of mate selection in the ovenbird:

> It is evident from the foregoing data that both male and female adult birds return to their old breeding grounds, if possible. Old males have a good chance of obtaining

their former territory either by arriving early or by driving out the other males. Returning females have more difficulty, however, since females probably return at more nearly the same time, and there is the additional factor in their adjustment, the male. It seems obvious, though it was not actually observed, that the female goes first to the old territory, and if the male there already has a mate, she goes to an adjoining territory. The particular male in the territory seems to be of no consequence.

In his house wren studies, Kendeigh (1941) found that more birds remated in subsequent years with their former mates than could be entirely a matter of chance. The chance of birds remating was greatly aided when they both returned to the former nesting grounds. The lack of remating was often due to a scattering of the birds into other, although near-by, areas.

Once two mice had become mated, they remained mated for the duration of that breeding season. Both mates of twenty-one pairs of mice survived long enough to produce more than one litter during the same breeding season. In all twenty-one cases the original mates remained paired for the production of their second or third litter which they produced in the same season. No mouse selected a new mate during one breeding season as long as its original mate was still living. Both mates of only three pairs survived a winter and produced a litter in their second breeding season. Two of these pairs remated, but both mice of the third pair, a father-daughter mating, selected new mates at the breakup of the winter aggregation and lived in adjacent nest boxes. The male had two mates during the previous fall, one of which was his daughter from an early fall litter. In the spring he was not remated with that daughter, but was again mated with his original mate and with a second daughter of a late fall litter of the previous breeding season. Two additional pairs were remated in the spring, but disappeared before litters were born. The rate of mortality was so great that individuals were constantly forced to select new mates. I believe it was merely chance and not recognition which resulted in three of the above four pairs of mice remating in the spring, and the chance of former mates remating in the spring is increased because mice which have bred in the previous breeding season do not disperse in the following spring.

Rate of Reproduction

The breeding season of the prairie deermice on the George Reserve extended, during the two years of study, from late March to early November. Of 675 immatures which I observed in the nest boxes, the following numbers of individuals were born, respectively, in each month: 4 in March, 164 in April, 45 in May, 37 in June, 19 in July, 13 in August, 217 in September, 150 in October, and 26 in November. The young in several of the first litters born in spring died before they were a week old. They were found dead but unmutilated in the nests with the females. The majority of the mice were born in September and October. April was the most productive month in the spring season. The number of litters was smallest in the months of July and August. Seven litters arrived as late as early November. In one of these litters, all five of the offspring appeared thin when they were six days old, and they all died on about the eighth day. Several litters were possibly missed during late summer, especially in August, when the nest boxes became warm and not as many mice used them.

It is difficult to determine the factors which regulate the breeding season in deermice. The interaction of many factors, namely, light, temperature, and quality of food, must have great influence. These factors were all found to affect the breeding of the fieldmouse (*Microtus agrestis*) by Baker and Ranson (1932: 1933). Whitaker (1940) showed with caged woodmice that increased light resulted in an increase in the rate of reproduction. Deermice which were kept in the laboratory under approximately uniform temperature and fed a nourishing diet, bred to a limited extent throughout the winter. Linduska (1942) reported deermice breeding during the winter in field-shocked corn in Michigan. He attributed this to a plentiful supply of food and cover. This winter breeding of deermice in the shocked corn was probably not merely the result of sufficient food and cover, for on the George Reserve the deermice were furnished ample nest boxes in which they stored quantities of food. Heape (1931) believed that the quality of food is important as a reproductive stimulus. It would be desirable to feed corn to deermice in the winter season, for the mice which bred in the shocked corn in the winter were feeding on this non-native food, which is supposed to be high in vitamin E content.

The number of litters and therefore the number of young produced in one breeding season or in one lifetime by a female prairie deermouse on the George Reserve depend upon the time of the year she is born. Females which are born between the latter part of March and the middle of May are likely to breed immediately upon maturing, which is usually at the age of four and one-half to nine weeks. If born after the middle of May, the females are not likely to breed until September. Females which are born before the middle of September usually breed in October. If they are not born until late in September or in October, they do not become sexually active for the first time until the following spring, and their first litter, therefore, is not produced until they are between twenty-four and twenty-seven weeks of age or older.

The arrival of deermice at breeding condition can be determined for the females by the appearance of their vaginas. Clark (1938) demonstrated for several subspecies of deermice other than *bairdii* that the females were sexually mature when their vaginas were open. He found that of 186 individuals the earliest age at the first estrum was twenty-eight days and the average was 48.7 days. In his experiments the youngest females were fifty days or more of age when they first conceived, but by checking mating records, he found two mutant *maniculatus* females which had both conceived at thirty-four days of age. Three litters were produced by female deermice on the George Reserve at the respective ages of approximately fifty-five, fifty-six (Fig. 24), and fifty-nine days. If the gestation period is assumed to be twenty-three days, the females must have conceived when they were but thirty-two, thirty-three, and thirty-six days of age, respectively.

The males were considered to be in breeding condition when the testes had become enlarged and were descended into the scrotum, but no studies have been conducted to determine the viability of the sperm at different seasons of the year. Clark (1938) reported that the males of several subspecies of *maniculatus* usually matured when they were about fifty-eight days of age and about ten days older than the females were when they reached maturity. Hamilton (1941*a*) found that male meadow mice (*Microtus pennsylvanicus*) may become sexually mature one week later than the females. If the female deermice mature sexually before the males of the same litter, the chance of inbreeding between sibs possibly may be reduced. Blair (1940*b*) estimated the youngest breeding male deermouse studied by him as being from five to six weeks old. I had one case in which presumably a male sired a litter with his sister when they both were about thirty-three (Fig. 24) days old, the gestation period being assumed to be twenty-three days.

It is possible for four generations of deermice to be produced during one breeding season. Females born in spring may produce a second generation in early summer. The females of the second generation may then produce a third generation in August or in early September, and these early fall-born offspring may produce a fourth generation in October. It is probable that four generations are commonly produced by deermice on the George Reserve. However, during this study two instances of three generations were the most that were observed to be born in one year. In one of these kindreds, the three generations were born in April, August, and October, respectively. In the other, the litters were produced in early April, late May, and September, respectively.

Theoretically, in an ideal environment, the reproductive potential of a pair of prairie deermice is the production of more than ten thousand descendants during the seven months' breeding season of one year. This assumes that the sex ratio in each litter is equal, that eight offspring are produced in each litter, that each female produces a continuous sequence of litters only twenty-four days apart, and that each female produces her first litter when she is fifty-six days old. This is an exorbitant number, and only a fraction of this number could be produced even in an ideal environment with 100 per cent survival. On the George Reserve the most successful pairs of deermice had only about a half dozen descendants in one season which reached sexual maturity.

Records were obtained of 185 litters, containing a total of 674 young deermice. One more litter was observed, but the female was still in labor when last seen so it is not included here. Of the 185 litters observed, there was an average of 3.64 young per litter, ranging from 1 to 7 individuals in each litter. There is evidence, however, that some mortality had occurred in the litters in which the young were advanced in age when found. In seventy-two of the 185 litters, in which the offspring were twenty-one days of age or older when I first found them, the average litter consisted of 3.28 individuals. The average was 3.39 individuals for the forty-six litters which were eight to twenty days old when first observed, 4.17 for the forty-two litters which were three to seven days of age, and 4.28 for the twenty-five litters in which the offspring were only up to two days old when found.

When stating the average litter size of a population, many factors have to be taken into consideration. The average litter size of the deermice studied varied from 3.28 to 4.28 individuals, depending upon the age of the immature mice when the litter was first examined. Miller (1946: 352) noted that fetal death and resorption occurs in pocket gophers (*Thomomys*), and he found an average decrease of roughly half an individual per litter during gestation. MacArthur (1944) demonstrated with the common house mouse that with selective breeding for body size, the females of the resulting larger race produced more individuals per litter than did the smaller females.

It was difficult to secure reliable information about length of gestation of the deermouse in the field. In one instance the female of a pair of mice in a nest box had an open vagina, and there was a milky mass in and around the vagina which was assumed to be semen. Svihla (1932: 10) has shown that females refuse to let males copulate more than a few times. If copulation of the above-mentioned mouse occurred on the day she was observed, her litter was born between twenty-two and twenty-three days later. In the laboratory Svihla (1932) found that the gestation for three females of *bairdii* ranged from twenty-three to twenty-seven days. He showed that the gestation period of the females of four subspecies of *maniculatus* other than *bairdii* was prolonged for as many as eight days with some females if they were lactating during the gestation period, but an increased number of embryos did not prolong gestation. The shortest interval that I found between litters produced on the George Reserve by the same female was twenty-four days.

Svihla (1932) reported considerable variation among his laboratory stocks of deermice in the period of suckling. The shortest period was twenty-two days and the longest was thirty-seven days. One twenty-five-day-old litter was nursing when their nest box was examined (Fig. 13). I have not analyzed the factors which bring about the weaning of the offspring, but with a caged female woodmouse (*noveboracensis*) I was able to prolong the period of lactation to approximately fifty-six days by furnishing her with additional immature young as the others matured. Her output of milk apparently began to decrease considerably between the fiftieth and fifty-sixth day, for two out of the five fifteen-day-old immatures died. The other three immatures died between the fifty-sixth and sixty-third day. She did not become pregnant after the birth of her own litter for no male was in her cage.

Home Range

The average linear distance which an individual prairie deermouse normally travels from its homesite during its nightly wanderings must be known before the rate of dispersal of these mice can be determined. Unless this linear distance is known, it is impossible to distinguish whether a movement made by a young deermouse is actually one of dispersal into a different breeding array within the deermouse population, or whether it is just the selection of a new nest site within the confines of its original home range.

The home range of a prairie deermouse is the area surrounding its homesite or nest over which the animal normally travels during its nightly wanderings (Burt, 1943). Since deermice are nocturnal, their home ranges cannot be determined by direct observation, although by new techniques (Southern, Watson, and Chitty, 1946) the movements of even nocturnal animals may be observed. So far, however, the average home ranges of small nocturnal mammals have been mostly determined by the live-trapping and marking of the animals. After the same animal has been trapped a number of times, the home range is usually given in terms of area, and the implication is that the animal regularly travels over the entire area which is enclosed by the points of its capture. Trapping and tracking records suggest that a mouse usually traverses different parts of its home range on successive nights. In the winter, as indicated by tracking, usually no two members of the same aggregation of mice traveled over the same ground during the same night. Most of the animals went some distance away from their home, but usually not more than a linear distance of four hundred feet from their nestsite, and they usually returned almost by the same routes which they had used when they left the nest box. In one night one animal, which was tracked on the snow, traveled more than two thousand feet, not including a few minor meanderings, but this animal was never more than eight hundred feet from its home. In the winter it was not unusual to find an entire aggregation of mice moving as far as five hundred feet and then taking up residence in a different nest box.

This investigation was not designed to determine the average size of the home range of a prairie deermouse, but some of the data, nevertheless, furnish an indication that the home ranges of these mice are many times larger than was formerly suspected. In his studies of the deermouse population on the George Reserve, Blair (1940*b*) calculated the average home range as being a little over one-half an acre. With another population of prairie deermice in Michigan, Blair (1942) recorded a slightly larger average home range size, but it still covered less than one acre. My limited amount of data suggests that a deermouse regularly travels over an area of five or six acres, and during one breeding season, a deermouse may traverse on different occasions an area ranging in size from five to ten acres (Fig. 16).

What are the data which suggest that the average, daily home range during the breeding season of a deermouse on the George Reserve possibly covers five or six acres? The figure is based on live-trapping records when the nest-box homesite was known for the animals which were trapped. Of twenty-eight deermice which were in a nest box during the day previous to the night when trapped or observed visiting another nest box, the following numbers of individuals were caught at the respective distances from their homesites: two at 50 feet; four at 100 feet; three at 150 feet; two at 200 feet; six at 250 feet; ten at 300 feet; and one animal at 350 feet. One female was trapped 250 feet from her week-old litter, which she again nursed after her release. A male with one hind leg missing was trapped 300 feet from his home. Another mouse, after I disturbed it by examining the nest box, moved 300 feet during the daylight hours to another box. A cache of sixty-five acorns was stored in a nest box which was 225 feet from the nearest oak tree. A male and his four offspring were trapped together at night 300 feet from the nest which the young were in during the previous day (Fig. 13).

These linear distances or radii of deermouse movements within a home range should not be converted to area and expressed in acres, for it is not known whether the nest of a deermouse is usually more or less in the center of its home range. Even if the homesites usually are in the center, to express the home range in terms of area greatly magnifies any errors made in determining the distance of movement. For example, a radius of 204 feet gives an area of three acres, but a radius only twice as great or 408 feet gives an area four times as large or twelve acres. Would it not be better to express the size of home ranges, which are only partly known, in terms of diameters or linear distances between points of capture rather than in terms of area?

I do not believe that the home ranges of small mammals can be determined at all accurately by traps set close together in a grid pattern (Blair, 1940*a;* Burt, 1940). The evidence on nightly movements which was obtained by trapping and tracking leads me to question the validity and advisability of checkerboard live-trapping in order to determine the size of the home range of small mammals. It is known that members of the genus *Peromyscus,* for instance, readily go into traps. The traps must, therefore, be set sufficiently far apart to give the animals an opportunity to go sometimes to the limits of their home ranges before they are caught. If the traps are spaced a sufficient distance apart so that the animals are not always caught in near-by traps, then the animals probably will not be caught very often. It will be difficult to make any mathematical calculation on how much farther the animals might have traveled beyond the trap if they had not been caught, since the distances between traps will then be great.

How might the average size of the home ranges of small mammals be determined by trapping? First, the homesite of one or more animals must be located by live-trapping with the traps placed close together. Then the traps must be relocated in order to determine the size of the home range of each individual whose homesite is known. The traps should be arranged in concentric lines or squares around the home of the animal. The spacing between the traps in each line should be approximately equal, possibly forty-five to sixty feet apart for most species of *Peromyscus.* The outermost line of traps should be set first. Then each day the line of set traps should be moved closer to the homesite of the animal until the individual concerned is caught. That part of the line of set traps could then be moved back a short distance. If the animal is not caught on the following night, the rest of the traps should again be moved closer to the animal's homesite. Nest boxes might serve as an excellent means of recognizing the homesite of an animal. Dice (1938; 1941) discussed several important factors to be considered when determining the size of the home range of a small mammal by trapping. Mohr (1947) reviewed many home-range studies and discussed the difficulties in trap-spacing in the grid system of determining the size of home ranges.

DISPERSAL MOVEMENTS

For the first two weeks of their lives young prairie deermice do not venture beyond the confines of their nests. As they become older they begin exploring the surroundings of their homes, and eventually probably become familiar with the home ranges of their parents. The young mice undoubtedly follow their parents about at times and thus gain experience. For example, as already mentioned, one father and his four offspring were all caught in the same trap three hundred feet from their home, and they certainly must have been traveling together.

The offspring, after they were weaned, and until just prior to sexual maturity, continued to remain in approximately the same home range which their parents occupied. No deermouse was known to have moved away from the area of its birthplace before it reached the stage in its reproductive development which just precedes the arrival at sexual maturity. One male only was known to have made an extensive movement after it had become sexually mature. He moved 2150 feet sometime between May 3 and May 17. Many deermice moved away from their birthplaces, however, just prior to becoming sexually active for the first time. The animals which were born between March and the middle of September usually became sexually active when they were four and one-half to seven weeks of age, but the offspring which were born later than the middle of September usually did not mature sexually until the following March.

Since many prairie deermice make dispersal movements from the area of their birthplaces at the time when their reproductive organs are becoming functional for the first time, it is suggested that part of the stimulus for these movements might be a direct response to a hormonal secretion by the reproductive organs. Slonaker (1924; 1927) recorded the rate of activity of albino rats in a revolving wheel and noted that females exhibited a marked increase in voluntary activity during each estrus. This rhythm of voluntary activity was not manifested prior to pubescence nor after the menopause. Young males, upon reaching puberty, exhibited a gradual average increase in daily activity similar to that of young females, but since the males do not experience heat cycles, their rates of activity did not fluctuate every four days. Cahn (1925) discussed internal urges as the cause of the more extensive movements made by many animals. He stated: "Thus migration becomes an adaptive response to gonactivity, and since this activity is a hormone secretion, migration becomes an effect to a hormone cause." He further pointed out that metabolic processes are speeded up by the activity of reproductive hormones. Considerable evidence has been obtained by many investigators which indicates that bird migration is in part a response to gonad activity.

Once a deermouse selected a breeding homesite, whether it was the same site of the animal's birthplace or whether it was at a considerable distance from the place where the individual was born, the deermouse remained in the general vicinity of its new home for the rest of its life. One male deermouse, however, whose mate had disappeared, moved 1250 feet sometime between April 24 and October 12, 1942. This is the only instance in which a deermouse made such a movement following the disappearance of its mate. Since this male was not observed for a period of almost six months, he may have established several new home ranges with the result that he eventually moved the total distance of 1250 feet.

No individuals which made any extensive movements away from their native home ranges were observed at intervening points between their birthplace and their newly established homesite. It is suggested, therefore, that each individual carried out its dispersal movement during a single night or during a brief period which included not more than several nights. Murie and Murie (1931: 203) demonstrated that a young female deermouse of the subspecies *artemisiae* was capable of returning a direct distance of "slightly over two miles in about 2 days" to its homesite.

Deermice which moved away from their birthplace did not usually aggregate in any of the more favorable nest boxes or home ranges. Deermice apparently possess the natural negative response, present in so many kinds of animals, to a crowding of their kind beyond a certain density within a limited area. Additional deermice did not occupy the extra nest boxes which were placed close to one another. This avoidance of crowding does not appear to be the result of antagonism between individuals, for various combinations with regard to sex and number occasionally were present together in the same nest boxes during the breeding season.

Of the many offspring which dispersed beyond the limits of the home range of their parents, only one animal was known to have retrogressed. This male moved 2050 feet away and then returned to breed in the same nest box where he was born. Since the mice presumably make their dispersals in a period of a day or two, possibly more of them retrogressed than were observed.

The greatest dispersal distance recorded for a prairie deermouse in this study was 3300 feet. The three hundred-acre study area was not large enough for a study of such extensive movements, and the chance of recovering very many individuals which traveled so far was slight. Blair (1940*b*) trapped a laboratory-reared deermouse 3960 feet from the point of its release, and he recaught one individual which had moved 3795 feet between his plots on the George Reserve.

TABLE I

Distances 155 Prairie Deermice Moved from their Birthplaces
Distances in Feet.

	0–500	550–1000	1050–1500	1550–2000	2050–2500	2550–3000	3050–3500	Totals
Males	53	14	5	2	2	1	0	77
Females	66	8	1	0	1	0	2	78
Totals	119	22	6	2	3	1	2	155

The exact proportion of the number of mice which made dispersal movements before they bred cannot be calculated, because it is impossible to determine how many animals moved off the George Reserve or into areas where there were no nest boxes (see also Figs. 9–24); nevertheless, the observed proportion of the animals which moved the various distances from their homesites is of value, for the percentage of individuals which actually moved such distances must be much greater. The greater the distance which a deermouse moved, the smaller was the chance that the individual would be observed again in another nest box. Of the total of 675 offspring for which the birthplaces are known, only 155 were used in the following calculations on dispersal movements (Table I). Before the movement of a deermouse was included in the figures below, the animal's birthplace and breeding site had to be known. If a mouse bred in more than one nest box, the average distance between its different breeding sites and its birthplace was used.

Of the 155 offspring which were observed again after they had begun to breed, seventy-seven were males and seventy-eight were females (Table I). Twenty-four (31 per cent) of the males and twelve (15 per cent) of the females moved at least 550 feet from their birthplaces. One hundred and nineteen of the 155 mice bred at their birthplaces or at locations not more than 500 feet from them. Of the thirty-six (23 per cent) animals which moved more than 500 feet, ten (13 per cent) of the males and four (5 per cent) of the females moved more than 1000 feet, five males and three females moved more than 1500 feet, three males and three females moved more than 2000 feet, one male and two females moved more than 2500 feet, and two females moved between 3000 and 3500 feet. The greatest distance an individual moved was 3300 feet.

Extensive individual dispersal movements of young animals is not a characteristic only of deermice. Burt (1940) reported three young woodmice which moved 800 to 900 yards from their birthplace. Fenyuk and Demyashev (1936) recovered two young gerbilles which had traveled 1000 and 1060 meters, respectively. Three young California ground squirrels moved more than 1200 yards (Evans and Holdenried, 1943). Errington and Errington (1937) and Errington (1944) recovered the following numbers of young muskrats which had moved the respective distances from their birthplaces: five, 500 to 950 yards; four, two to four miles; and one, twenty-one miles. Stuewer (1943) obtained returns from fourteen juvenile raccoons which traveled three and one-half to twenty-seven miles from their birthplace. With regard to the movements of young fox squirrels, Allen (1943) reported that one animal was shot approximately forty miles from its birthplace. Two red fox pups were killed at distances of sixteen and eighteen miles from where they were born, but in different directions. One young fox was shot 160 miles distant from the place from which it had escaped from captivity (Errington and Berry, 1937). Farner (1945) has reviewed the dispersal distances in many published records on birds. One robin was found during the breeding season at a distance of 425 miles from its birth locality. Nice (1937) found two song sparrows which had made a dispersal movement of 1300 to 1400 meters from their birthplace. Buss (1946) recaught two ring-necked pheasants two miles from where they were banded. For an extensive review of the distances of dispersal of small organisms, see Wolfenbarger (1946). Eyles (1944) made a critical review of the literature on the dispersal of anopheline mosquitoes, and a dispersal of several miles is apparently not uncommon for certain species.

It was demonstrated on the George Reserve that young deermice will on occasion disperse through unfavorable habitats such as woods. Such movements are also characteristic of many other species of mammals. One citation from the literature will suffice. Anthony (1923) observed picas (*Ochotona*) on several occasions "in the mountains of southern Colorado, miles from anything that could be regarded as their natural habitat."

As has been stated earlier, deermice made their dispersal movement, if they moved at all, just before they became sexually mature. The same is true for many vertebrate species; Burt's (1940) statement about woodmice is typical: "Dispersal of individuals in this species occurs chiefly while the animals are young and before they have established their homes. Once an animal selects a homesite it rarely leaves, but usually remains there for the rest of its life."

INBREEDING

Almost nothing is known about the extent of inbreeding which occurs in natural populations of vertebrate animals. Few investigators have conducted a study of any natural population of animals in such a manner as to be able to learn how much inbreeding occurs. Nice (1937: 36) found one brother and sister song sparrow, from the same nest, which mated in the following spring. All three of their eggs hatched. Shelley (1932) reported a brother-sister mating in downy woodpeckers, but upon examining his published data, it does not appear to be a valid case of inbreeding. Clobes (1936) noted an instance of father-daughter mating between swallows in Germany. Blair (1940*b*) reported on one presumed case of father-daughter mating in deermice.

In the population of prairie deermice studied, I found ten instances of presumed close inbreeding and seven additional instances where close inbreeding possibly occurred. Of the ten instances of presumed inbreeding, eight were father-daughter matings and two were between sibs. Of the seven possible instances of inbreeding, two were between a father and daughter, two were between a mother and son, and three were between a brother and sister.

With regard to the total of twelve presumed and possible instances of parent-offspring matings, it is interesting to note that ten of them were matings between a father and daughter, and only two were matings between a mother and son. This can possibly be explained on the basis that a far greater proportion of the male offspring moved away from their birthplaces before breeding than did females, therefore reducing the chance for mother-son matings to occur.

Of the eight presumed father-daughter matings, four of them produced a litter, but one of these was possibly a father-granddaughter mating instead of a father-daughter mating; the female of one mating was in an advanced stage of pregnancy when she was last observed; two sisters had open vaginas and were with their father when they were last observed in the spring; and one other daughter had an open vagina when she was last seen with her father (Figs. 2 and 3). Both instances of possible father-daughter matings produced a litter.

Two possible instances of mother-son matings were noted (Fig. 4). Both pairs produced a litter.

Of the two instances of presumed brother-sister matings, one pair moved 1250 feet, apparently together, and produced one litter during the same season in which they were born (Fig. 3). They also remated the following spring. In the other case of a presumed mating between sibs, the two individuals had been born in late fall but in different litters. Neither of them dispersed the following year; instead, they remained at their birthplace. The female was in an advanced stage of pregnancy when she was last seen. In all three of the instances in which inbreeding possibly occurred between a brother and sister, there was more than one male living in the nest boxes with each female (Figs. 2, 4, and 5).

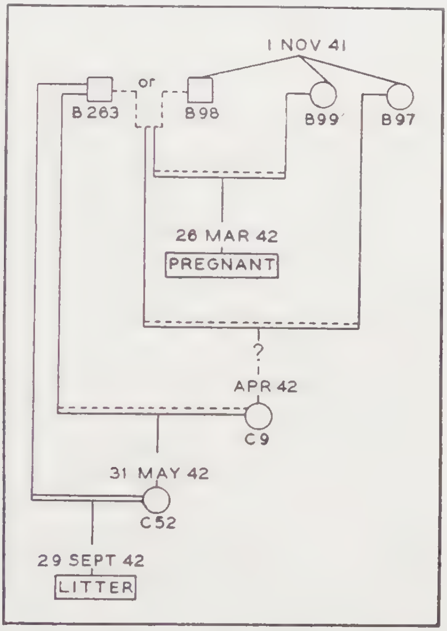


FIG. 2. The three sibs (♀ B97, ♂ B98, and ♀ B99) and the unrelated male (♂ B263) were observed together on March 26, 1942. ♀ B97 and ♀ B99 were both in an early stage of pregnancy as indicated by their recently closed vaginas. The sibs had remained together since their birth on November 1, 1941. ♂ B263, born on October 18, 1941, 250 feet away, was first observed with the other three mice on March 26, 1942. It is not known whether ♂ B98 fertilized one or both of his sisters, or whether ♂ B263 fertilized one or both of the females. Possibly both males impregnated one or both females.

♀ B99 was not seen again.

♀ C9 was presumably produced by ♀ B97 sometime between April 5 and April 24. ♀ C9 was fertilized by ♂ B263, which was either her father or an unrelated male, and she produced ♀ C52 sometime between May 31 and June 19.

♀ C52 was fertilized by ♂ B263, which was either her grandfather or father. She produced a litter on September 26, which was the third generation produced during that year.

It is not known whether deermice breed promiscuously when several pairs simultaneously occupy the same nest. If they are promiscuous, several more cases of inbreeding possibly took place, for in several instances an offspring and its possible mate lived together in the same box with both parents.

A more intensive study of this same deermouse population would probably demonstrate the presence of an even greater proportion of close inbreeding. By analyzing my breeding data on deermice, I find the study was not sufficiently intense to enable me to state what proportion of the offspring was the result of close inbreeding, but it is estimated on the basis of this field study that at least 4 to 10 per cent of the litters observed were produced by parent-offspring matings or matings between sibs.

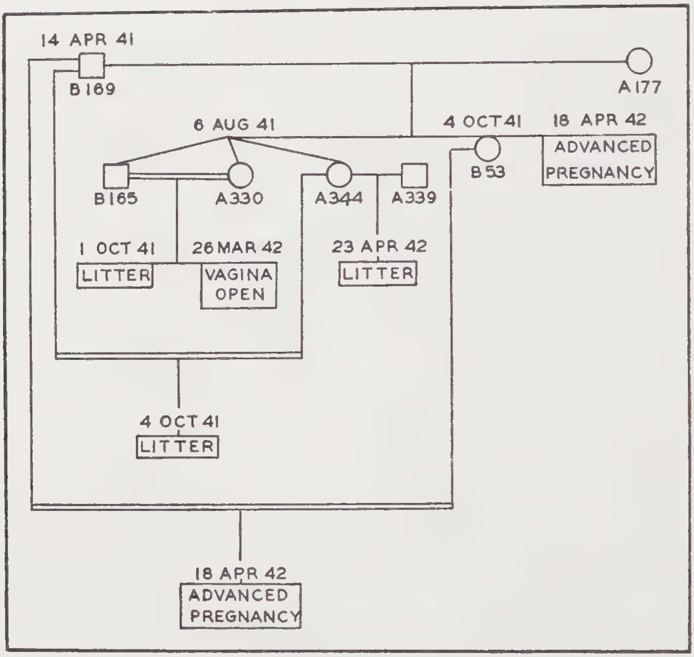


FIG. 3. ♀ A177 and ♂ B169 produced ♀ A330, ♀ A344, and ♂ B165 about August 6, 1941 (see also Fig. 24).

♀ A330 and her brother (♂ B165) moved 1250 feet, produced a litter on October 1, and were together on March 26, 1942, at which time ♀ A330 was in breeding condition. ♀ A330 was not seen again, and ♂ B165 was observed with a new mate on May 4.

♀ A344 produced five young (♂ B164) by her father (♂ B169, see also Fig. 23) about October 4, 1941. ♀ A344, however, was not mated with her father the following year. Instead, she produced a litter by an unrelated male (♂ A339).

♂ B169 bred with ♀ A177 again, at about the same time he bred with his daughter (♀ A344), and ♀ A177 produced ♀ B53. In the spring of 1942, ♂ B169 presumably impregnated his daughter (♀ B53) and ♀ A177. Both females were advanced in pregnancy when they were observed on April 18 with ♂ B169. The three animals were not seen again.

Wright's (1922) coefficients of inbreeding and relationships could not be effectively applied to the entire population or to any one of the known pedigrees because of the limited amount of knowledge about the consanguineous matings. For each of the above-mentioned cases of parent-offspring and brother-sister matings, the coefficients of inbreeding would be 25 per cent. There was one possible case in which a male may have mated successively with both his daughter and with his granddaughter; the coefficient for this would be 37.5 per cent. It is possible, theoretically, for a male only sixty-six weeks old to sire his great-great-great-great-great-granddaughter, since eight generations can be produced in two breeding seasons. Such a male, however, would have to be born not much later than May 17 in order to be able to sire three generations during the same year in which he was born. The first litter in the breeding season of the next year would have to be produced about March 31 in order that the female producing the eighth generation could be fertilized as early as August 21.

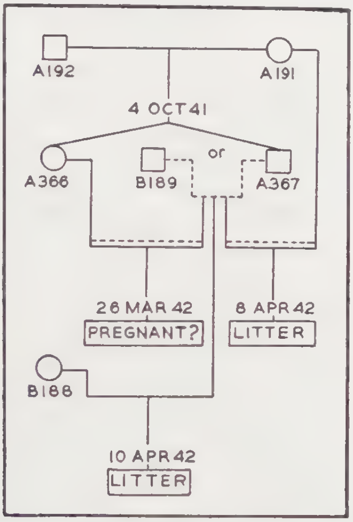


FIG. 4. ♀ A191 produced ♀ A366 and ♂ A367 about October 4, 1941. On March 26, 1942, ♀ A191, her daughter (♀ A366), her son (♂ A367), and ♀ B188 and ♂ B189 were together. ♀ B188 and ♂ B189 apparently were not related to the other three mice, although they were first observed with the others on February 8.

♀ A366 was last seen March 26 at which time she was pregnant. She was probably fertilized by either her brother (♂ A367) or the unrelated male (♂ B189).

On April 18, ♀ A191 and her three ten-day old young, ♀ B188, her four eight-day old young, ♂ A367, and ♂ B189 were observed together. It is not known whether ♀ A191 was fertilized by her son (♂ A367) or by the unrelated male (♂ B189).

All of the mice which were observed in the several nest boxes cannot be connected to the same pedigree because too many mice from the surrounding deermouse populations moved into the study area. With very little additional continued live-trapping in critical areas, however, it would have been possible to determine the degree of kinship of practically the entire population of deermice. In the most complete pedigree obtained, I was able to ascertain the relationship of 175 mice. Six generations were represented in one of the pedigrees, which shows that five generations were produced during the two years of the study.

Several factors tended to reduce the rate of inbreeding in the deermouse population on the George Reserve. The prairie type of habitat was continuous with surrounding regions of grassland and most of the adjacent woodland was less than one-half mile wide, thus there was not a complete barrier to movement of deermice into the study area. It has been shown earlier that apparently just before maturing sexually, more than half of the young mice moved away from the home range of their birthplace. This characteristic movement of young mice greatly reduces the chance of parent-offspring matings. The chance of brother-sister matings is possibly reduced, since apparently female deermice characteristically mature at an earlier age than do the males.

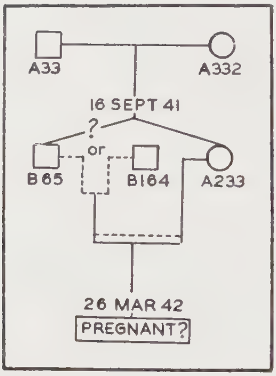


FIG. 5. ♀ A233 and ♂ B65 were born to ♀ A332 and ♂ A33 on about September 16, 1941.

On March 26, 1942, ♀ A233 and ♂ B65 were with an unrelated male (♂ B164) which had moved a distance of 1000 feet. ♀ A233 was pregnant at that time, but it is not known whether her brother (♂ B65) or the unrelated male (♂ B164) had impregnated her.

Even though the deermouse population studied appeared highly social, there is the possibility that assortative mating might occur for certain genetic characters. Blair and Howard (1944: 18) reported that selected color strains of laboratory-reared individuals of the same population of Chihuahua deermice (*Peromyscus maniculatus blandus*) tend to pair assortatively under the conditions of the laboratory experiment. Philip (1938) and Haldane (1938) found assortative mating was almost certainly occurring in a population of not more than a few hundred house mice in a Scottish coal mine where the types yellow-belly and grey-belly existed as two mating units.

LENGTH OF INDIVIDUAL SURVIVAL

Since the field work was conducted for only two years, it is difficult to give the maximum age prairie deermice reach under natural conditions. Only eight mice are known to have lived on the Reserve for more than seventy-three weeks. Four males lived at least 104, eighty-three, seventy-six, and seventy-four weeks, respectively. Four females lived at least seventy-eight, seventy-seven, seventy-six, and seventy-six (Fig. 8) weeks, respectively. My only evidence that senility is seldom reached in the deermouse population is that the four females were either advanced in pregnancy or nursing young when they were last observed, and there were litters present in the nest boxes with two of the above four males when they were last observed. All of the above eight mice bred during the previous year.

TABLE II

Longevity in Prairie Deermice

Age by Nearest Week	Per cent of Deermice to Reach the Different Ages		
	322 Individuals	169 Individuals Born in Spring, Summer, or Early Fall	153 Individuals Born in Late Fall
0	94	90	98
1	85	78	94
2	74	53	86
3	56	38	76
4	51	31	73
5	46	25	70
6–10	39	17	64
11–15	34	15	56
16–20	29	13	46
21–25	18	11	27
26–30	8	8	8
31–35	5	7	3
36–40	4	5	3
41–45	2	4	2
46–50	2	2	1
51–55	0.3	1	0
56–60	0.3	1	0
61–65	0	0	0

The life history of every individual in each litter is known for all of the 322 deermice which are included in Tables II–V. If a litter was born in a location near an edge of the study plot, the individuals are not included because of the difficulty in determining how many of them might have disappeared by moving off the area being studied rather than by being killed.

In the laboratory many individuals of *bairdii* have been kept for two or three years, but no tests for longevity in prairie deermice have been carried out. Dice (1933*a*) kept one animal of the subspecies *gracilis* for eight years in the laboratory. In the oldest fertile pair of *gracilis* that Dice recorded, the female was more than four years of age and the male nearly six years old. The rigors of nature are of such magnitude that it is very doubtful that any prairie deermouse in the field ever reaches old age and senility.

The principal causes of mortality in the deermouse population studied are not known, but predation is assumed to be the most important factor. Foxes dug around several of the nest boxes. One marked deermouse recovered by F. N. Hamerstrom, Jr., had been cached in the snow by a fox. Murie (1936) found remains of specimens of *Peromyscus* (*bairdii* and *noveboracensis*) in only 5.2 per cent of the fox trail droppings which he examined from the Reserve. Lawrence Camburn frightened one raccoon which was attempting to get into a nest box. Van Harris caught four least weasels while trapping for specimens of *bairdii* not many miles from the George Reserve, but this species of weasel is not abundant in this region. Six blue racers were found in nest boxes. The boxes probably made the mice less susceptible to predation from hawks and owls, since they served as additional refuges for the mice.

Cannibalism may have accounted for the mortality of some immatures, but the method of study did not give definite evidence on this matter. In laboratory stocks of mice the parents occasionally devour their offspring. I found that adult deermice usually remained highly social even under starving conditions, but if one of them died the others might eat it.

Diseases and parasites probably did not kill many of the mice, for had that been the case some weakened or diseased individuals would have been observed in the nest boxes. A male deermouse, which had appeared healthy on April 13, 1941, was dead one week later, on the ground about twelve inches from the entrance to a nest box. This animal showed no signs of physical injury, and his stomach was full. No evidence suggests that competition between individuals is a direct cause of mortality in deermice.

Unfavorable weather associated with shortage of food caused some mortality in the month of March. As a result of the marked fluctuations in spring weather conditions in Michigan, there is little doubt that many deermice died while living in their natural burrows, since cold waves occasionally came after many of the fall-born mice had moved away from their winter aggregations and since their burrow entrances occasionally became plugged during sleet storms or when freezing weather followed a thaw. Most of the deermice which did not disperse had exhausted their food stores by early spring. The nest boxes possibly increased the rate of survival of the mice during this period of the year, for the outer entrances of the nest boxes projected above the surface of the ground, and the tunnel was frozen closed in only one box. The deermouse which was living in this box was alive. After cold waves, however, mice were found dead in the nest boxes in March. They apparently had died of starvation during the cold weather. On March 23, 1941, three mice curled up together in a nest were found dead. Two of the animals had lived in that nest box during the winter, but the third mouse, a male, had moved a distance of 1350 feet since March 1. Possibly, unfavorable spring weather is an important mortality factor for the deermouse in the northern limits of its range. Even though summer heat probably reduces the rate of reproduction in deermice, there was no known mortality resulting from summer weather.

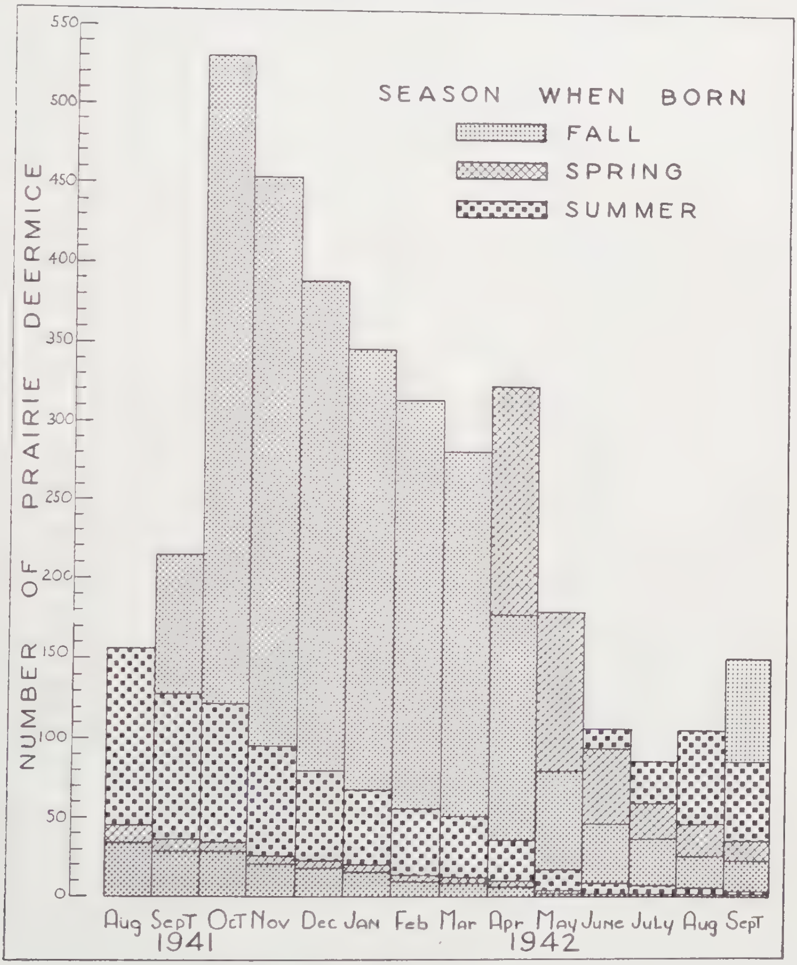


FIG. 6. Monthly changes in the density and structure of the prairie deermouse population, according to the season when the 1135 individuals were born.

In the winter when plant growth is suspended, the quantity and quality of food may become a critical factor with the mice, although the rate of mortality was lower during midwinter than at other seasons. With a lowered environmental temperature, active deermice require a considerable increase in daily food consumption, and an active mouse will die within one or several days, depending upon its supply of body fat, when it is deprived of food at freezing temperatures. Under certain undetermined conditions, however, some of the deermice became torpid; this greatly reduced their metabolic activity and enabled them to survive on considerably reduced rations (Fig. 6).

With an ample food supply, mice apparently can withstand severe weather. From February 6 to March 10, 1947, two wire cages containing woodmice (*noveboracensis*) were placed outdoors at the Laboratory of Vertebrate Biology. A single animal was in one cage and three were in the other cage. The animals were given no nesting material or protection from the winds and snow, but they were supplied with a surplus of food. It did not seem necessary to continue the experiment any longer, because the mice remained healthy and active even though the temperature dropped to 6° F. one night. They were exposed to many below-freezing winds, and snow occasionally collected on their backs.

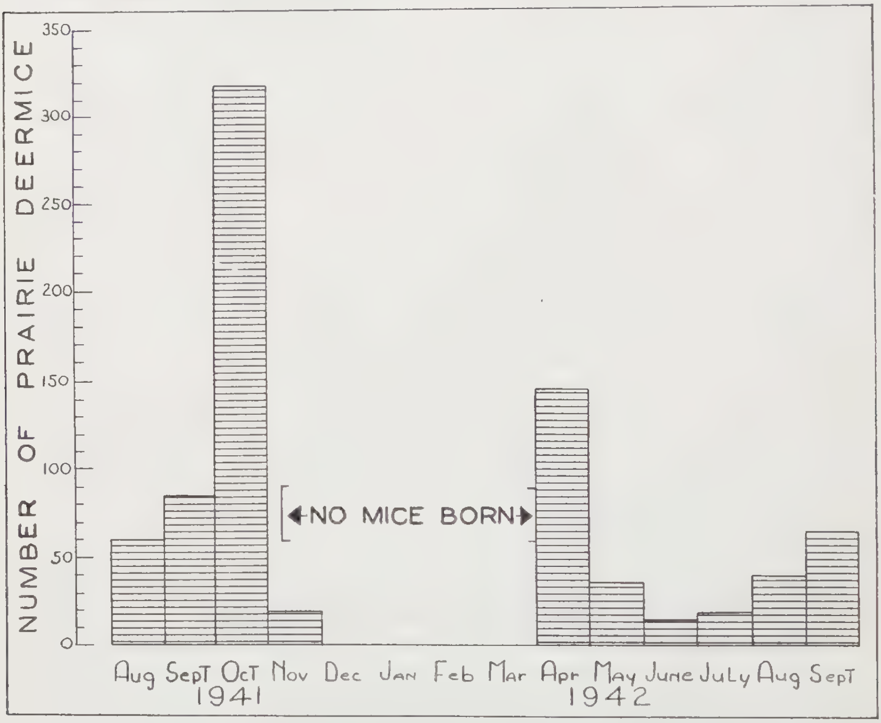


FIG. 7. Number of prairie deermice which were known or estimated to have been born in each month.

There were marked seasonal fluctuations in the abundance of prairie deermice on the George Reserve (Figs. 6 and 7). According to the nest-box and live-trapping records the population attained its maximum density about the last week in October. During late fall the population density of deermice living in the study area was five times that present during the summer months. The rate of mortality was low and uniform during the winter months in comparison to the spring and summer seasons; 62 per cent of the individuals present in November were still alive in March; whereas only 13 per cent of those alive in March were still present in July. The rate of mortality of both young and adult mice was high during the spring months. The great amount of spring mortality was the result of increased predation, occasional late snow and sleet storms, and the increased exposure of deermice to unfavorable weather and predation, since most of the deermice which make dispersal movements away from their place of birth do so in that season. There was not much breeding during the the spring months except for the litters which were born in April. There was very little breeding during the summer months, and, consequently, the population was at its lowest ebb in the late summer.

TABLE III

MORTALITY TABLE OF 322 PRAIRIE DEERMICE

Age by Nearest Week	Number of Individuals		Probability	
	Living	Missing	Living	Missing
0	322	20	.94	.06
1	302	27	.91	.09
2	275	36	.87	.13
3	239	58	.76	.24
4	181	17	.91	.09
5	164	15	.91	.09
1–5	302	153	.49	.51
6–10	149	22	.85	.15
11–15	127	16	.87	.13
16–20	111	19	.83	.17
21–25	92	34	.63	.37
26–30	58	31	.47	.53
31–35	27	11	.59	.41
36–40	16	3	.81	.19
41–45	13	5	.62	.38
46–50	8	3	.62	.38
51–55	5	4	.20	.80
56–60	1	0	1.00	.00
61–65	1	1	.00	1.00

The probability of living was calculated for the mice in the same manner as in the "American Experience Mortality Table" (Hodgman, 1941: 317), in which the probability that an individual will die, or in the case of the mice, will disappear, is determined by dividing the number of individuals which are missing by the number which are living in each age group.

The chance for a spring-born mouse to attain three weeks of age is much less than that for a fall-born animal (Fig. 8). Weather probably accounts for much of this spring mortality of immature mice. The chance of surviving to the age of ten weeks is much less for a mouse which matures sexually during the same year it is born than it is for a mouse which is born after the middle of September and does not become sexually active until the

TABLE IV

MORTALITY TABLE OF 169 PRAIRIE DEERMICE WHICH BECAME SEXUALLY MATURE IN THE SAME SEASON IN WHICH THEY WERE BORN

Age by Nearest Week	Number of Individuals		Probability	
	Living	Missing	Living	Missing
0	169	17	.90	.10
1	152	21	.86	.14
2	131	24	.82	.18
3	107	43	.60	.40
4	64	11	.83	.17
5	53	11	.79	.21
1–5	152	110	.28	.72
6–10	42	13	.69	.31
11–15	29	3	.90	.10
16–20	26	4	.85	.15
21–25	22	5	.77	.23
26–30	17	3	.82	.18
31–35	14	3	.79	.21
36–40	11	2	.82	.18
41–45	9	3	.67	.33
46–50	6	2	.67	.33
51–55	4	3	.25	.75
56–60	1	0	1.00	.00
61–65	1	1	.00	1.00

following spring. This is partly because the rate of mortality is high at the time of sexual maturity when so many mice disperse from their birthplaces. Since more males than females make dispersal movements, the rate of mortality is greater for males at this period of movement.

TABLE V

MORTALITY TABLE OF 153 PRAIRIE DEERMICE BORN IN THE FALL AND NOT MATURE SEXUALLY UNTIL THE FOLLOWING SPRING

Age by Nearest Week	Number of Individuals		Probability	
	Living	Missing	Living	Missing
0	153	3	.98	.02
1	150	6	.96	.04
2	144	12	.92	.08
3	132	15	.89	.11
4	117	6	.95	.05
5	111	4	.96	.04
1–5	150	43	.71	.29
6–10	107	9	.92	.08
11–15	98	13	.87	.13
16–20	85	15	.82	.18
21–25	70	29	.59	.41
26–30	41	28	.32	.68
31–35	13	8	.38	.62
36–40	5	1	.80	.20
41–45	4	2	.50	.50
46–50	2	1	.50	.50
51–55	1	1	.00	1.00
56–60				
61–65				

The sex ratio of the 516 deermice which were found when immature was 250 (48 per cent) females to 266 (52 per cent) males. Of the 537 mice which were mature when first observed, there were 273 (51 per cent) females to 264 (49 per cent) males. Mortality is greater with the sexually mature females than it is with the sexually mature males during the breeding season; therefore, with mice which have bred the sex ratio is about even.

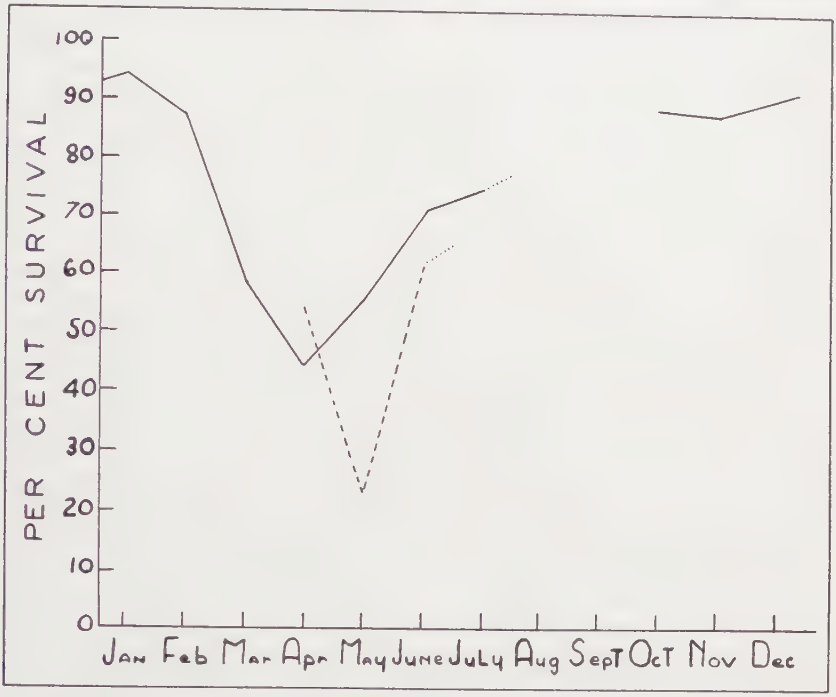


FIG. 8. The curves indicate the chance in per cent which each prairie deermouse present at the beginning of any month had of being alive at the end of that month. The curve (———) is based upon the length of survival of 318 deermice which were born in October; the curve (- - - -) is based upon the length of survival of 193 deermice which were born in April; and (. . . .) indicates an insufficient number of individuals from which to draw a curve.

SUMMARY

One hundred and thirty-six nest boxes, which were mostly buried 150 to 300 feet apart over approximately 300 acres of grassland in southern Michigan, have given much information about the dispersal movements and the amount of inbreeding of the prairie deermouse (*Peromyscus maniculatus bairdii*). Many of the mice made their homes in the nest boxes and even produced many of their young in them. More than 1200 prairie deermice were marked, and these were observed more than 4000 times. The mother and in most cases also the father were known for the 675 deermice which were born in the nest boxes.

The prairie deermice which lived together in the nest boxes were usually mates or members of the same family. Adult deermice generally occurred in pairs during the breeding season, but there were three instances in which two families lived together in the same nest box, and in areas where the sex ratio of the adult mice was unequal, as many as three males lived with one female and as many as three females lived with one male during the breeding season.

Young mice which are born after the middle of September do not mature sexually until March of the following year. Since prairie deermice do not move from the area of their birthplace until they approach sexual maturity, family aggregations consisting of the parents and their fall-born young of one or two litters frequently occur and persist through the winter.

Most of the deermice were born in September and October, and except for a few which were born during the summer months the remainder were produced from late March to early May. Two instances were observed in which three generations of mice were produced during one breeding season, and it is likely that four generations occasionally may be produced in one year.

There seems to be no bar to the mating of close relatives. Parent-offspring mating and pairing between sibs occurred when the conditions were such that these related mice happened to be together at the time when they became sexually active. Mated mice remained together throughout the breeding season if they both survived. Because of the high rate of mortality, however, frequent selection of new mates was necessary.

The data obtained by examining the nest boxes at night and by live-trapping suggest that the average size of the daily home range of prairie deermice might be as large as five to six acres, and that both male and female deermice may, on different occasions during a breeding season, travel over as great an area as five to ten acres.

The study area was not large enough to make possible the recovery of deermice which made extensive dispersal movements away from their birthplaces. The greatest distance which a deermouse was observed to have moved from his birthplace to his breeding homesite was 3300 feet. At least 30 per cent of the males moved 550 feet or more from their birthplaces before producing offspring, whereas only 15 per cent of the females moved such distances.

Ten instances of presumed inbreeding between sibs or between parents and their offspring were noted. Additional possible cases of close inbreeding are discussed in this report. On the basis of this field study, it is speculated that at least 4 to 10 per cent of the 186 litters observed were produced either by parent-offspring matings or by matings between sibs.

It is doubtful that any prairie deermice reach old age and senility, since the oldest animals which were observed were one and one-half to two years in age, and they apparently had remained fully fertile. Less than one-fifth of the deermice reached sexual maturity. Approximately one-quarter of those individuals which were born either in spring, summer, or early fall survived to five weeks of age, whereas approximately one-quarter of the deermice which were born after the middle of September reached twenty-one to twenty-five weeks of age. Of the prairie deermice observed, the probability of living for another week of age was least when the animals were only about three weeks old. Predation and cold weather accompanied by a shortage of food appeared to be the principal causes of mortality in the deermice.

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APPENDIX

SELECTED EXAMPLES OF THE DISPERSAL MOVEMENTS OF PRAIRIE DEERMICE

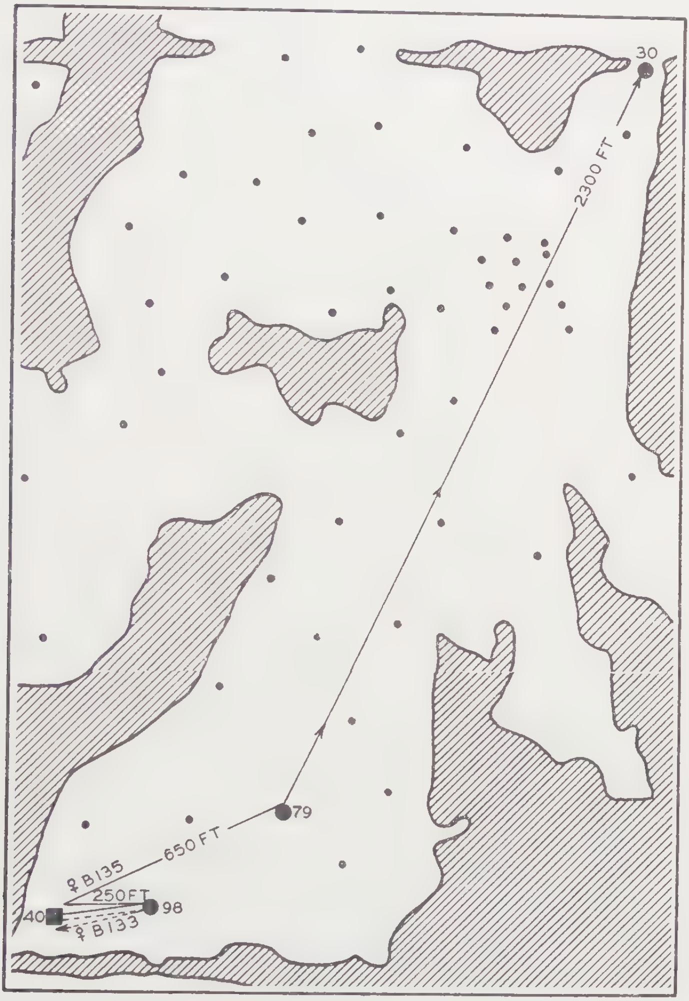

FIG. 9. ♀ B133 and ♀ B135 were born November 2, 1941, in box 40 (Map 1, C-5). The family moved to box 98 and back again to box 40 during the winter. ♀ B133 later produced a litter in box 40. ♀ B135 was observed in box 79 on March 19, 1942. Then she moved 2300 feet to box 30, where she had several mates, the first of which had an extra toe on the outside of his right front foot. This male disappeared before she became pregnant, but she produced a litter with her second mate.

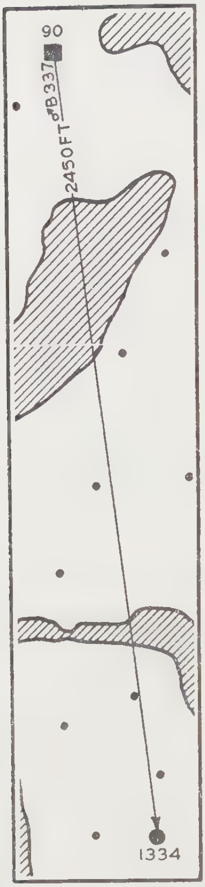

FIG. 10. ♂ B337 was born about April 16, 1942, in box 90 (Map 1, C-4). His father was probably also his mother's father. ♂ B337 had a white spot on his forehead. He moved 2450 feet to box 1334 where he was observed on July 24 with a female. Also in the box were three live bumblebees and their eggs. ♂ B337 was last seen on October 12, the end of the field study, in box 1334 with a different female.

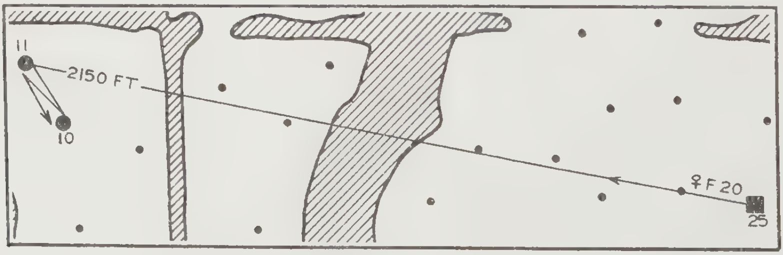

FIG. 11. (Map 1, B-5). ♀ F20 was born in the fall of 1940. She was in box 25 on March 1, 1941. By April 6 she had moved 2150 feet to box 11. At that time her vagina was open, and she was with a male woodmouse (*noveboracensis*). She later mated with a prairie deermouse and produced two litters in box 10. Her first litter produced in box 10 was two days old when observed. Six days later when the box was again examined something had eaten the young mice, and ♀ F20 was in box 11.

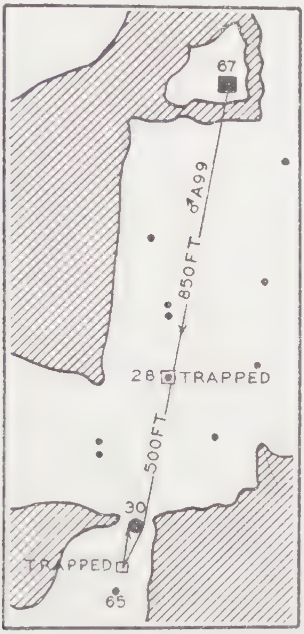

FIG. 12. ♂ A99 was born in box 67 and moved to box 30 and its vicinity (Map 1, D-6). He and his mate and two of their litters occupied box 30 during the winter. Of the twelve mice in the box on November 27, 1941, five of the young were dead, possibly from suffocation. Four of them were about one week old, but the other one had been born in October. At this time there was 1050 cc. of weed seeds, 565 acorns, and six deer pellets in the box which had been cached sometime between October 26 and November 27. It was 120 feet to the nearest branch of an oak tree. ♂ A99 was last seen on April 24, 1942, in box 30 with his same mate and a litter.

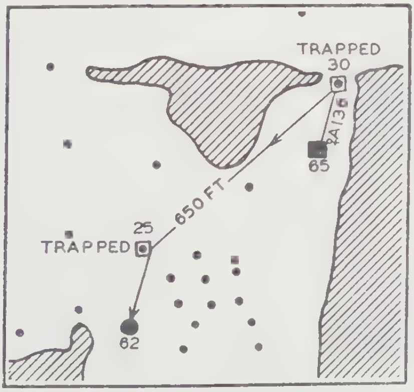

FIG. 13

FIG. 13. ♀ A136, one sister, and two brothers were born about June 29, 1941, in box 65 (Map 1, D-5). They were in box 65 on July 19 with their mother. That night the four young mice were trapped 300 feet from their home at box 30 with their father. All five individuals were trapped at one time in a single-catch live trap. ♀ A136 produced three litters in 1941 in box 62. On November 27 she was nursing young which were twenty-five days old when the box was examined.

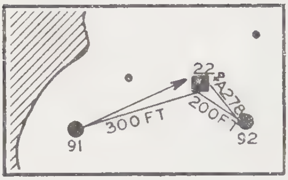

FIG. 14

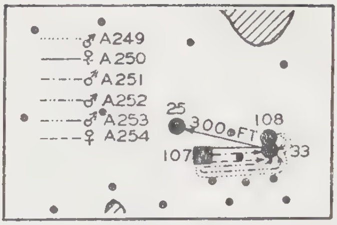

FIG. 15

FIG. 14. ♀ A278 was born about September 21, 1941, in box 22 and remained there during the winter (Map 1, C-5). From March 4, 1942, to August 3 she was observed twelve times in either box 22, 92, or 91. On four of the twelve observations she had an open vagina. On two occasions she had a recently closed vagina. Three males were regularly observed with her. All three of the males were with her on five of the twelve times she was seen between the above dates. On five of the observations only two males were with her, and on two of the occasions just one male was seen with her. By August 3 she was forty-five weeks old and had not reared a single litter and had not been advanced in pregnancy.

FIG. 15. A litter of six (♂ A249, ♀ A250, ♂ A251, ♂ A252, ♂ A253, and ♀ A254) was born about September 29, 1941, in box 107 (Map 1, C-5). On October 26 the father joined the family group, and they were all in box 33. On November 8 there were two offspring from an earlier litter and a third litter of four young seven days old also in the box. On November 27 and December 17 thirteen related mice were still in box 33. This included both parents, two offspring from the first litter, five offspring from the second litter, and the four offspring of the third litter. ♀ A250 was the only member of the litter of six young which was seen again after winter had passed, and she produced a litter in box 25.

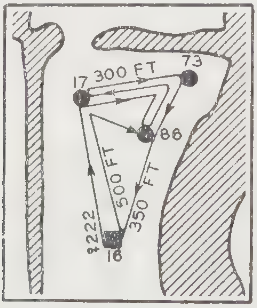

FIG. 16

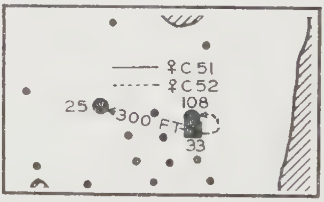

FIG. 17

FIG. 16. ♀ 222 was first observed as an adult on November 24, 1940, in box 16 (Map 1, B-5). During 1941 she produced four litters, possibly lost a fifth, and was observed either pregnant or with a litter in boxes 16, 17, 73, and 86. She was seen for the twenty-fourth and last time on March 26, 1942, in box 86 in advanced pregnancy. She was then seventy-six weeks old and had been observed with 29 different prairie deermice for a total of 105 times. She had three mates, outliving two of them.

FIG. 17. ♀ C51 and ♀ C52 were born to ♀ C9 and ♂ B263 about May 31, 1942, in box 33 (Map 1, D-5). ♀ C51 raised a litter, which was a third generation produced in 1942, in box 25. Another third generation litter was produced by ♀ C52 in box 108. ♂ B263 presumably sired ♀ C52, who was his daughter if not his granddaughter, making the offspring possibly the great-grandchildren of ♂ B263.

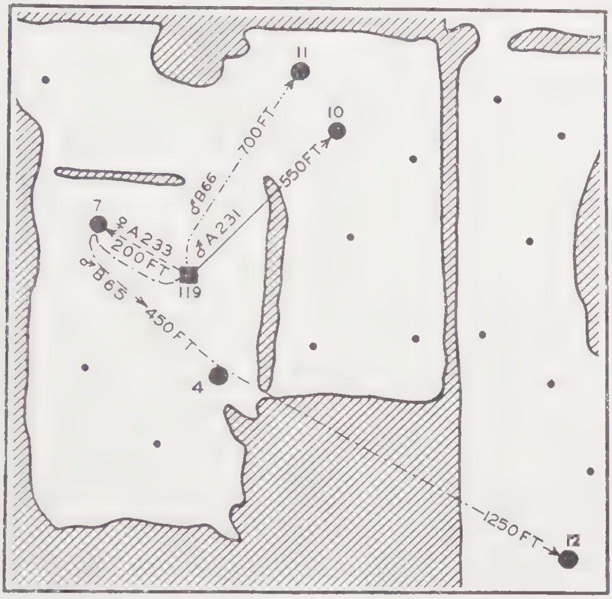

FIG. 18. A litter of five (♂ A231, ♀ A233, ♀, ♂ B65, and ♂ B66) was born about September 16, 1941, in box 119 and remained there through the winter (Map 1, A-5). On March 26, 1942, ♂ A231 had moved 550 feet to box 10 where he remained, ♀ A233 had moved 200 feet to box 7 where she was last observed pregnant, ♂ B66 had moved 700 feet to box 11 where he remained, and ♂ B65 was also in box 7 with ♀ A233 with another male who had come a distance of 1000 feet. ♂ B65 was in box 4 on April 24. Six months later he was in box 12, a distance of 1250 feet from box 4.

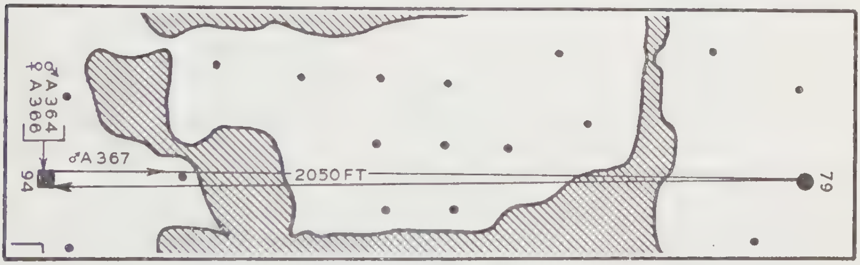

FIG. 19. ♂ A367 (see also Fig. 4) was born in box 94 with two brothers and one sister about October 4, 1941 (Map 1, C-2). One borther was not observed again and the other brother (♂ A364) was seen for the last time on February 8, 1942. ♂ A367 was in box 79 on March 19 but retrogressed and was back in box 94 on March 26 with his pregnant sister (♀ A366), who was not seen again, their mother, and three unrelated mice, two females and one male. ♂ A367 was last observed in box 94 with his mother, another female, a male, and two litters which were eight and ten days old respectively.

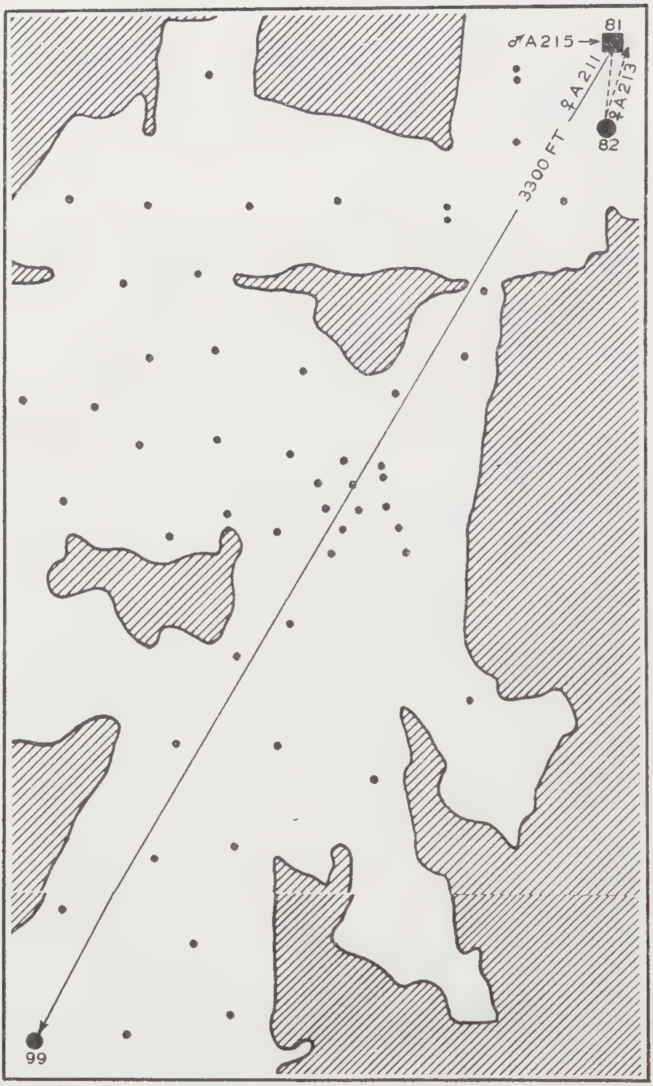

FIG. 20. ♀ A211, ♀ A213, ♂ A215, and two more daughters were born in box 81 about September 11, 1941 (Map 1, C-5). ♀ A211 moved 3300 feet to box 99 where she was seen on October 22 with a male. ♂ A215 was last seen at his birthplace on October 19 with ♀ A213 and their father. ♀ A213 was last seen in breeding condition on March 19, 1942, with an unrelated male, at her birthplace.

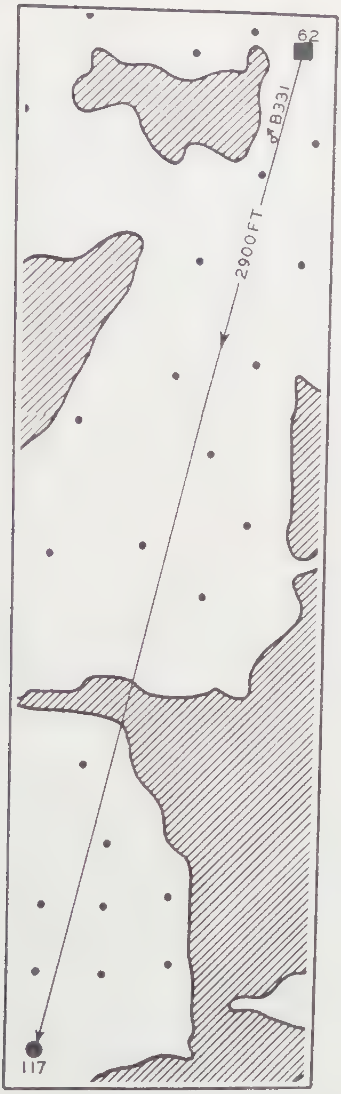

FIG. 21. ♂ B331 was born in box 62 about April 22, 1942 (Map 1, C-4), moved 2900 feet, and was last observed October 12 in box 117 with a mate and three offspring.

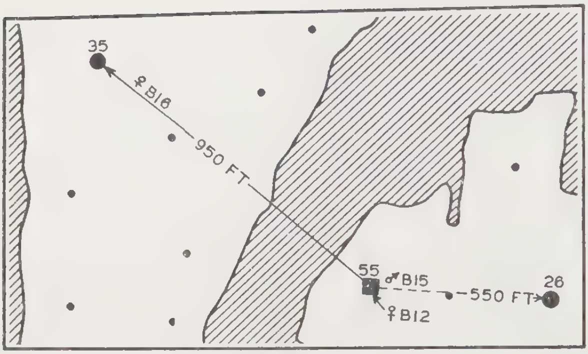

FIG. 22

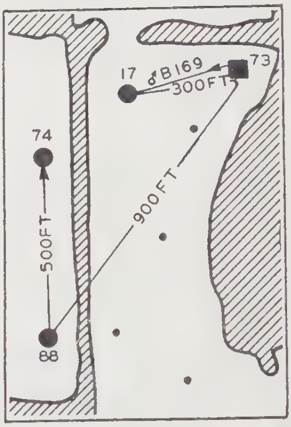

FIG. 23

FIG. 22. ♀ B16 was one of a litter of five born about October 11, 1941, in box 55 (Map 1, C-6). The family remained in box 55 during the winter. Her brother, ♂ B15, moved 550 feet to box 26 where he was observed on March 19, and he had sired two litters there by June. Her sister, ♀ B12, was not yet in breeding condition when last seen on March 26 still in box 55 with her mother and three unrelated mice.

FIG. 23. ♂ B169 (see also Figs. 3 and 24) was born in box 73 (Map 1, B-5). He moved to box 88 where he sired his second litter with one of his daughters (♀ A344) born to ♀ A177. During the same season he went to box 74 where he stayed during the winter with ♀ A177 and some of his offspring. He was last seen in box 74 the following spring with ♀ A177 and another daughter (♀ B53), and both females were pregnant.

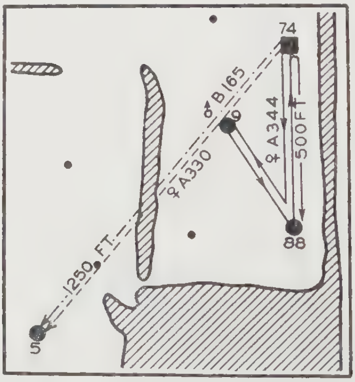

FIG. 24. ♀ A330 and ♂ B165 were born in box 74 along with ♀ A344 (see also Figs. 3 and 23; Map 1, A-5). Then they moved 1250 feet to box 5, in which they produced a litter when only about fifty-six days old. This litter completed the third generation born in that year. ♀ A344 produced a litter in box 88, which was sired by her father (♂ B169) in 1941, and another in 1942, which was sired by an unrelated male.

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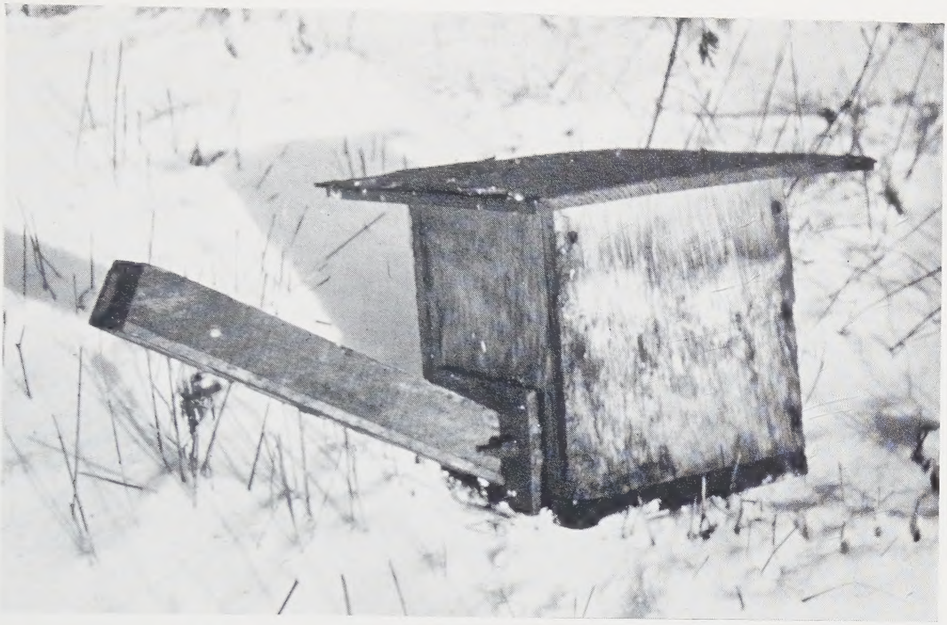

FIG. 1. Nest box exposed on surface of the ground.

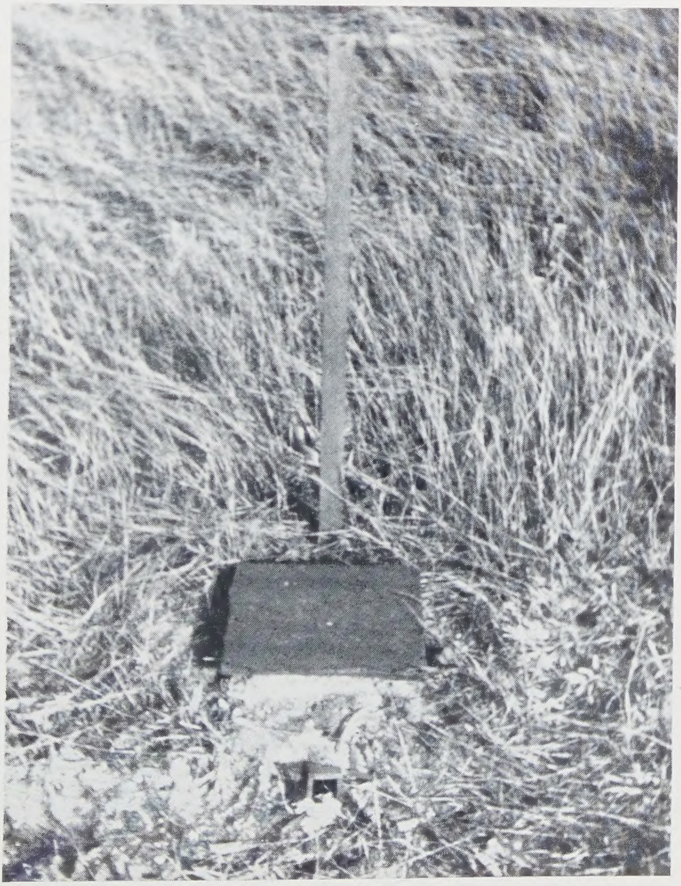

FIG. 2. Nest box buried in the field and entrance to the tunnel.

PLATE II

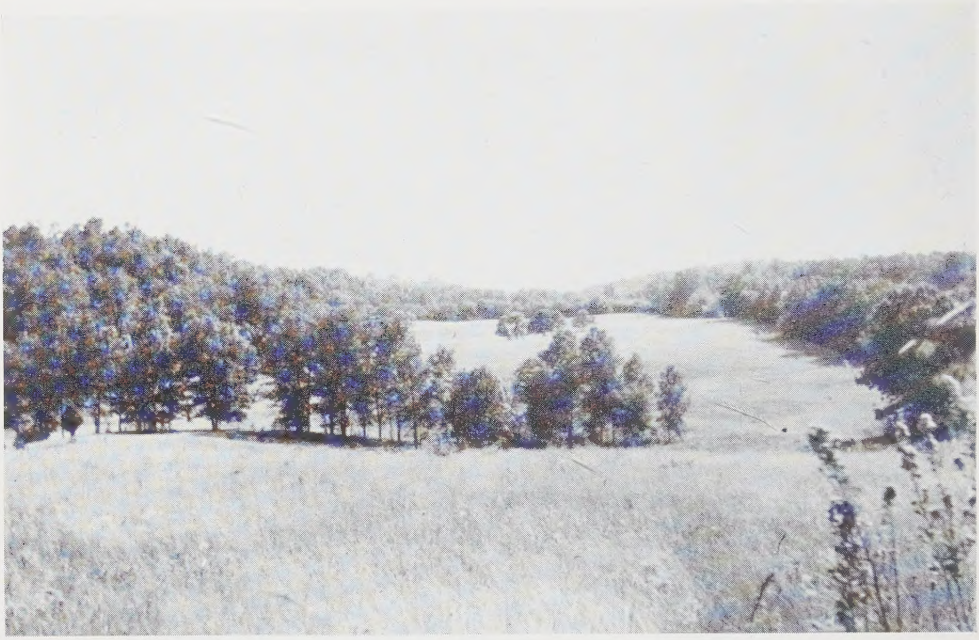

FIG. 1. Twelve nest boxes were in this area of grassland on the George Reserve.

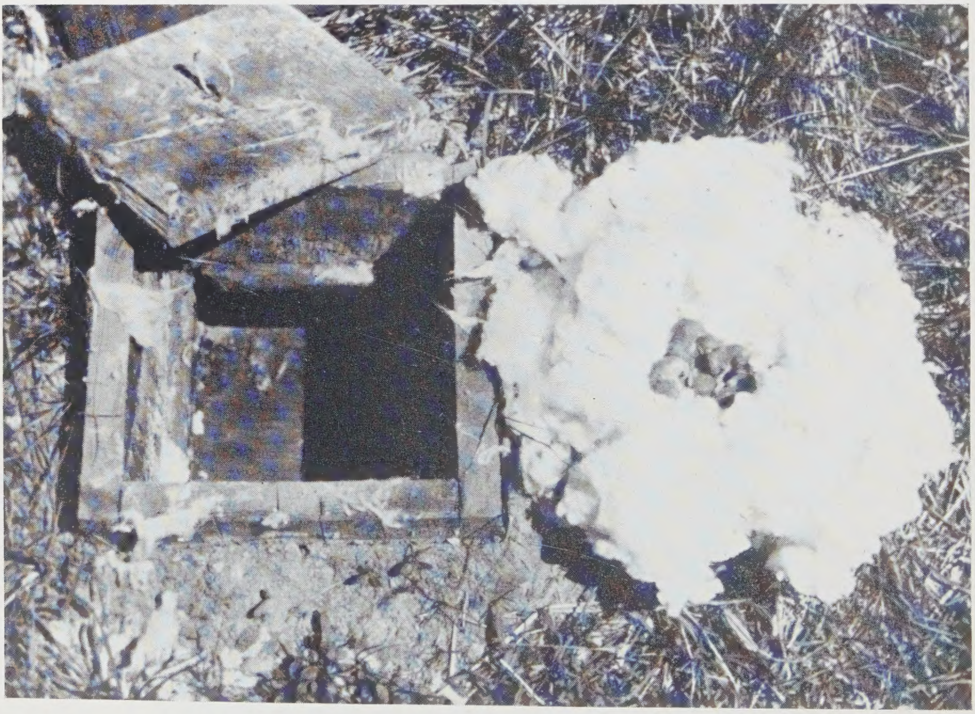

FIG. 2. A litter of prairie deermice four days old.